THE PRINCIPLES AND PRACTICE OF OPHTHALMIC SURGERY

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THIS BOOK IS

AFFECTIONATELY DEDICATED

TO

MY WIFE, L. L. S.

PREFACE TO THE THIRD EDITION

The author has been gratified by the reception given to the earlier editions of this work. In the preparation of this new edition much new material has been added to the text and many new illustrations have been included. These additions bring the contents fully up to date and make this presentation complete. The unusual demands made upon our ophthalmic surgeons through battle casualties have been seriously considered and have been covered in the expansion of the material dealing with traumatic conditions. The section on Muscles now properly includes a discussion on the Physiology of Squint and the section on Ptosis and its etiological factors has been rewritten to a great extent.

In the presentation of a surgical text for the eye, it is necessary that ophthalmology be considered as a branch of internal medicine having a definite surgical aspect. The author has attempted to include all surgical operations which are a part of his own practice, as well as certain other procedures which are well known (or even not well known) and generally approved. No attempt has been made to make the book encyclopedic, for experience in medicine and in surgery is the greatest of teachers. This truism has been the greatest single reason for the following pages. The operating room and the dissecting room are the places where one learns to practice surgery, but first it is necessary that the student-physician and the physician know of possibilities, probabilities, and potentialities. These are the fundamental factors which the author has tried to cover.

Quoting Berens: "An operation on the eye, if it is carefully planned and executed, tests the surgeon's knowledge of medicine as well as his technical skill. Medical knowledge implies not only a thorough understanding of the etiology of the eye, the physiology and pathologic anatomy of the part to be operated on, but also a general knowledge of the patient's general physical condition and mental reactions."

The author takes this occasion to express his gratitude for the many frank and generous reviews which were accorded to the previous editions. Throughout this text an attempt has been made to give credit where credit is due. Surgery, no matter which branch is being considered, is the result of the knowledge and the efforts of men of all nations and of all races. No one person has added much to the general field. Certainly this is true in recent years. In individual problems, however, quite the opposite is true. To be specific, the author has quoted verbatim at great length from Stallard, and from Walker; for these men are so definitely authoritative in their respective fields that it was necessary to do this in order to present the subject matter of radium therapy, and the surgery of retinal separation in satisfactory and adequate detail, and to give due credit where so much credit is deserved. It has been necessary to consult text-books and many monographs to make this book as complete as it could be for the student of ophthalmology as well as for the practicing ophthalmologist. The author has repeatedly used extracts and quoted verbatim from authoritative works. In each instance the source of the quotation has been given and

if an illustration has been used its origin has been given. Such indebtedness seems best expressed here in the preface. If failure to give credit has occurred, it has been an oversight and it is regretted.

The author wishes to thank Dr. Thomas Cowan for his assistance with the Surgical Anatomy of the Globe, Dr. Ramon Castroviejo for the text on Keratoplasty, which has brought this subject up to date, and Dr. Otto Barkan of San Francisco for his section on Goniotomy. The gracious criticisms from many readers in regard to Earlier Editions have been responsible for many additions to this volume. I have drawn on the writings and opinions of many of these verbatim. It is proper to do this, because such expressions were the result of extensive experience. The opinion and the advice of such men as Benedict, Spratt, O'Connor, Esser, Gradle, Thorpe, Regan, Shipman and Krewson, are, but to mention a few of these, of inestimable value. Thanks are expressed to The Blakiston Company, of Philadelphia, for their permission to incorporate the author's Ophthalmic Plastic Surgery, as revised, within this volume.

Indebtedness is acknowledged and thanks are given to the editors and publishers of: *Archives of Ophthalmology; American Journal of Ophthalmology; Surgery, Gynecology and Obstetrics; Transactions of the American Academy of Ophthalmology and Oto-laryngology; Year Book of Eye, Ear, Nose and Throat;* to P. Blakiston's Son & Co., publishers of Meller's Surgery, Beard's Surgery, Wolff's Pathology of the Eye; to the C. V. Mosby Company, publishers of Duke-Elder, Vol. No. 1; to the Oxford Medical Publications, for permission to use material from Whitnall, Anatomy of the Eye and the Orbit, and Gillies' Plastic Surgery; to the W. B. Saunders Company, publishers of Berens' Textbook of the Eye; and to my own publishers, Lea & Febiger, for matter from Török and Grout, Atkinson's External Diseases of the Eye, Peter's Extra-ocular Muscles, and from Hunt's Plastic Surgery of the Face; and for the use of many illustrations The assistance, and many courtesies of my publishers, Lea and Febiger, are gratefully acknowledged and sincerely appreciated.

Indebtedness is acknowledged to my secretary, Miss Barbara Wiltbank, for her assistance with the manuscript and the proof, to Mrs. M. S. Wright for her proof reading, and to the illustrator, Mrs. Gladys Bronstein, for her invaluable and loyal assistance.

Wilmer's phrase,[1] "Suaviter in modo, fortiter in re" is passed on to the student as an admonition, and to the established ophthalmologist as a mutual possession, it is hoped; and as an ideal for all our efforts.

E. B. S.

PHILADELPHIA, PENNSYLVANIA

[1] From Foreword "Newer Method of Ophthalmic Plastic Surgery," Spaeth, P. Blakiston's Sons & Co Philadelphia, 1926

CONTENTS

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

CHAPTER VI

THE PHYSIOLOGY OF STRABISMUS SURGERY OF THE OCULAR MUSCLES. INSTRUMENTS. ANESTHESIA. SURGICAL TECHNIQUE

CHAPTER VII

THE ESSENTIALS OF RECONSTRUCTIVE OPHTHALMOLOGICAL PLASTIC SURGERY. FREE SKIN EPIDERMAL AND DERMAL GRAFTS. FAT, FASCIA AND MUSCLE GRAFTS. MUCOUS MEMBRANE GRAFTS

CHAPTER VIII

THE ESSENTIALS OF RECONSTRUCTIVE OPHTHALMOLOGICAL PLASTIC SURGERY. PEDICLE FLAPS

CHAPTER IX

SURGICAL CONDITIONS OF THE LIDS

BLEPHAROSPASM PATHOLOGICAL CONDITIONS OF THE SKIN, AS XANTHOMATA, BENIGN AND MALIGNANT TUMOR MASSES, CYSTS, CHALAZION. HORDEOLUM (STYE) BLEPHAROCHALASIS. BAGGY LOWER LIDS

CHAPTER X

Surgical Conditions of the Lids—*Continued*

Disturbances of the Palpebral Fissure Ankyloblepharon Cicatricial Notching of the lids. Loss of Cilia. Sinuses About the Canthi Temporary and Permanent Tarsorrhaphy. Obliquity of the Palpebral Fissure. Canthotomy and Canthoplasties Colobomata. Epicanthus The Surgical Treatment of Lagophthalmos, Exophthalmos, Enophthalmos Atrophy of *the Retrotarsal Tissues of the Upper Lids*

CHAPTER XI

Surgical Conditions of the Lids—*Continued*

The Lid Surgery of Trachoma Tarsus Resections Blepharoptosis

CHAPTER XII

Surgical Conditions of the Lids—*Continued*

Ectropion Trichiasis Entropion. Cul-de-sac Reconstruction Pemphigus (Essential Atrophy of the Conjunctiva)

CHAPTER VI

THE PHYSIOLOGY OF STRABISMUS. SURGERY OF THE OCULAR MUSCLES. INSTRUMENTS. ANESTHESIA. SURGICAL TECHNIQUE

CHAPTER VII

THE ESSENTIALS OF RECONSTRUCTIVE OPHTHALMOLOGICAL PLASTIC SURGERY. FREE SKIN EPIDERMAL AND DERMAL GRAFTS. FAT, FASCIA AND MUSCLE GRAFTS. MUCOUS MEMBRANE GRAFTS.

CHAPTER VIII

THE ESSENTIALS OF RECONSTRUCTIVE OPHTHALMOLOGICAL PLASTIC SURGERY. PEDICLE FLAPS

CHAPTER IX

SURGICAL CONDITIONS OF THE LIDS

BLEPHAROSPASM. PATHOLOGICAL CONDITIONS OF THE SKIN, AS XANTHOMATA, BENIGN AND MALIGNANT TUMOR MASSES, CYSTS, CHALAZION. HORDEOLUM (STYE). BLEPHAROCHALASIS. BAGGY LOWER LIDS

CHAPTER X

SURGICAL CONDITIONS OF THE LIDS—*Continued*

DISTURBANCES OF THE PALPEBRAL FISSURE. ANKYLOBLEPHARON. CICATRICIAL NOTCHING OF THE LIDS. LOSS OF CILIA SINUSES ABOUT THE CANTHI. TEMPORARY AND PERMANENT TARSORRHAPHY. OBLIQUITY OF THE PALPEBRAL FISSURE. CANTHOTOMY AND CANTHOPLASTIES. COLOBOMATA. EPICANTHUS THE SURGICAL TREATMENT OF LAGOPHTHALMOS, EXOPHTHALMOS, ENOPHTHALMOS *ATROPHY OF THE RETROTARSAL TISSUES OF THE UPPER LIDS*

CHAPTER XI

SURGICAL CONDITIONS OF THE LIDS—*Continued*

THE LID SURGERY OF TRACHOMA TARSUS RESECTIONS BLEPHAROPTOSIS

CHAPTER XII

SURGICAL CONDITIONS OF THE LIDS—Continued

ECTROPION. TRICHIASIS. ENTROPION CUL-DE-SAC RECONSTRUCTION. PEMPHIGUS (ESSENTIAL ATROPHY OF THE CONJUNCTIVA)

CHAPTER XIII

Surgical Conditions of the Lids—*Concluded*

Cicatricial Incisura of the Lids. Forms of Blepharoplasty for Lid Reconstructions

CHAPTER XIV

Anatomical Factors Connected With Surgical Procedures on the Eyeball

CHAPTER XV

Surgical Conditions of the Conjunctiva

CHAPTER XVI

Surgery of the Sclera and the Cornea

CHAPTER XVII

SURGERY OF THE IRIS AND THE ANTERIOR CHAMBER

CHAPTER XVIII

ETIOLOGY AND DIFFERENTIAL DIAGNOSIS OF CATARACT. GENERAL CONSIDERATIONS CONNECTED WITH CATARACT SURGERY

CHAPTER XIX

THE TECHNIQUE OF THE CATARACT OPERATIONS INDICATIONS AND CONTRA-INDICATIONS FOR VARIED PROCEDURES

CHAPTER XX

Complications of Cataract Surgery

CHAPTER XXI

Surgical Indications in the Glaucomas

CHAPTER XXII

The Surgery of Glaucoma in Specific Instances. The Surgery of Glaucoma as It Applies to the Iris

CHAPTER XXIII

Surgery of Glaucoma—*Concluded*

CHAPTER XXIV

THE ETIOLOGY AND DIAGNOSIS, THE INDICATIONS AND CONTRAINDICATIONS IN TREATMENT OF RETINAL SEPARATION

CHAPTER XXV

THE SURGICAL TREATMENT OF RETINAL SEPARATION

CHAPTER XXVI

TRAUMATISMS OF THE GLOBE AND LIDS PERFORATING INJURIES OF THE GLOBE SYMPATHETIC OPHTHALMIA. INTRA-OCULAR FOREIGN BODIES; MAGNETIC AND NON-MAGNETIC

CHAPTER XXVII

ROENTGEN-RAY AND RADIUM THERAPY. MALIGNANCY IN AND ABOUT THE ORBIT AND THE GLOBE. PLASTIC REPAIR OF TUMOR SITES

PRINCIPLES AND PRACTICE OF OPHTHALMIC SURGERY

CHAPTER I

ANESTHESIA. PREOPERATIVE PROCEDURES. POSTOPERATIVE PROCEDURES. THE RÔLE OF THE ASSISTANT. OPERATING ROOM TECHNIQUE. INSTRUMENTS

ANESTHESIA

It is not uncommon to see a properly performed surgical operation nullified, in its effects, by improper or unwisely selected anesthesia. It is even more unfortunate to be unable to proceed with a surgical operation for the same reason. No one form of anesthesia will lend itself to all cases. Even cocain, which is certainly the most universal of anesthetics used in ophthalmological surgical procedures, is strongly contraindicated in some circumstances. All forms must be utilized, but only when indicated. By this is meant, instillation anesthesia, injection and infiltration anesthesia, nerve blocking, inhalation anesthesia, intravenous anesthesia and anesthesia by rectum.

For minor purposes, cocain is probably the most universally used. Four per cent cocain in an aqueous solution, with or without the addition of adrenalin chloride, gives a satisfactory anesthesia for many of the more superficial operations. It dilates the pupil, however, and dries the cornea, is mildly irritating and deaths have occurred under rare circumstances. The addition of adrenalin chloride does enhance its effects, and decreases its general absorption. Butyn has been used and has been recommended. Individuals are found who are sensitive to it, and the resulting conjunctivitis with edema of the lids, the pain and the general distress which follow, make its use unsatisfactory. Undoubtedly it is used considerably, but because of the many complications reported its use routinely must be taken under serious consideration. Pontocain, a patented product of tetracain, is quite satisfactory for many surgical operations. The drug may be used in a 0 5 or 1 per cent solution, and can be made up as necessary from a 2 per cent stock solution. The drug sterilizes itself, does not dilate the pupil nor dry the cornea, and the anesthesia lasts longer than does that from cocain. Chemically, pontocain is para-butylamino-benzoyl-dimethyl-amino-ethanol. Due to the fact that it does not affect the superficial epithelial cells of the cornea, pontocain instillation is satisfactory for retinal separation surgery and for the removal of intra-ocular foreign bodies, with or without adjunct general anesthesia. This is important in that not uncommonly one must use an ophthalmoscope during the operation in such instances. (A preparation has appeared rather recently on the market for similar surgery which seems to give an even deeper tissue penetration anesthesia. This prepara-

tion is known as larocain. Chemically it is not dissimilar to pantocain.) Occasional minor surgical procedures are necessary to the canaliculi and the lacrimal sac. A cocain solution will take care of these, but pontocain is somewhat better because of a deeper though slower penetration.

Holocain hydrochloride is not an especially satisfactory anesthetic for any surgical procedure. It gives sufficient anesthesia for taking the ocular tension and for removing superficial foreign bodies from the cornea, but with this exception it has no great surgical value.

Injection Anesthesia.—Cocain, in 0.5 to 1 per cent solutions and novocain (procain hydrochloride) are the two ideal solutions for this. Considerable infiltration can be carried out with drugs of these strengths. The injections are used, sub-conjunctivally, into the depths of the superior and inferior cul-de-sacs in sufficient amount to balloon them out, along the sheaths of the ocular muscles, and for retrobulbar anesthesia. If there are no contraindications to the use of adrenalin chloride, the anesthetic action is enhanced by the addition of 1 part in 100 of a 1 to 1000 adrenalin chloride solution. Novocain should not be used in diabetics for infiltration anesthesia unless the blood sugar is well under control as it has resulted in sloughing of the infiltrated tissues on non-standardized diabetics. Infiltration is not especially successful in the correction of cicatricial defects due to a distortion of the tissues. Muscle surgery may need 2 per cent novocain for infiltration in many instances to render the operation more nearly painless. A temporary paralysis of the orbicularis oculi is desirable during certain intra-ocular operations. In general, however, the catastrophies which result from a patient squeezing his eyelids are less common than those resulting from the forcible retraction of the eyeball by the four recti muscles. If this observation is correct, temporary paralysis of the facial nerve, according to O'Brien's method, is not as important a procedure as is the retrobulbar injection of the ciliary ganglion. Wright[1] however states that O'Brien's akinesia has given cataract operators an invaluable aid in technique when dealing with unruly and uneducated patients. Infiltration at the outer canthal angle into the fibers of the orbicularis above and below is usually sufficient for the control of the lids and if a canthotomy must be done a similar amount may be further injected directly into the canthal angle.

Nerve Blocking.—Nerve blocking is, in general, quite satisfactory for surgery about the orbit, for the lacrimal sac, and of assistance in plastic surgery of the lids as adjunct to avertin anesthesia. Two per cent novocain with adrenalin is to be used. The supra-orbital, and the infra-orbital nerves, the ciliary ganglion, and akinesia of the seventh nerve are to be considered.[2] The frontal nerve, the trochlear, the lacrimal, and the zygomatic-facial nerves are all at times of importance. The supra-orbital nerve can be injected through the skin in the superior orbital notch; this is felt along the superior orbital margin at the junction of the inner and middle thirds. This nerve supplies the major portion of the upper eyelid. The infra-orbital nerve, also injected in its foramen and also palpable through the skin, lies below the level of the inferior orbital margin at its mid-line. When injecting the infra-orbital nerve, the needle should be directed temporally slightly upward, and backward. This nerve supplies

[1] Am. Jour Oph Series 3, vol. 16, March, 1933.
[2] O'Brien, Jour Am Med Assn, 8, 90, January 7, 1928.

the major portion of the lower eyelid, the canthal angles, and the lacrimal sac. This anesthesia must be augmented for lacrimal sac surgery under a local anesthesia, especially dacryocystorhinostomy, by the direct application of 10 per cent cocain, applied against the middle turbinate with well wrung out cotton wound nasal applicators and gauze nasal packing. Adrenalin may be added to this strength of cocain to prevent absorption. The two trochlear nerves can be blocked by injections at the trochlear process. The lacrimal nerve can be blocked at the orbital margin, laterally, just below the zygomatic-frontal suture line The zygomatic facial nerve can be blocked by an injection, 8 to 12 mm. below, and the same distance laterally, from the external canthal angle. The facial nerve is blocked by injecting 2 cc. of novocain solution directly over the condyle of the mandible. When this is used, the lids must be temporarily sutured, after the surgical procedure, for it would be disastrous to permit the eyelids to remain open after intra-ocular surgery, as this will occur if the orbicularis has been adequately paralyzed. (Fig. 1.)

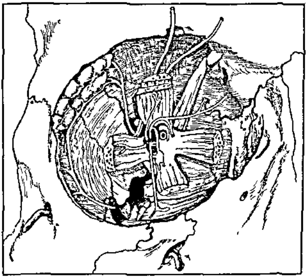
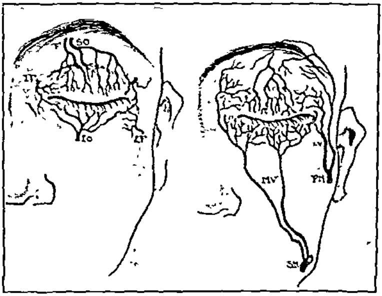


FIG. 1.—Dissection to show the nerves of the orbit including the zygomatic-facial nerve below and laterally, and the infra-orbital nerve below and in the mid-line (Modified after Wolff.)

The ciliary ganglion is blocked by an injection through the conjunctiva in the superior cul-de-sac with the patient looking to the opposite side and with the needle directed backward, downward, and slightly nasally. It is passed until the point of the needle touches the lateral wall of the bony orbit. The needle is withdrawn the least bit, the point moved slightly more nasalward, advanced another ½ centimeter, and 1 cc. of the solution injected, depending upon the prominence of the eyeball prior to the injection. It is unwise, in cataract surgery, to use retrobulbar anesthesia with a prominent eyeball. The blocking can also be achieved through the inferior cul-de-sac, with the patient looking to the opposite side, the point directed up, and in. Many operators inject directly through the lower lid at the inferior outer angle of the orbit, the needle passing below the inferior cul-de-sac and directed slightly more upward than when directed through

the cul-de-sac. Any one of the three procedures is satisfactory. Figure shows the position of the various nerves as they lie about the orbit, and t site for injection in nerve blocking. The needle is used for retrobulb anesthesia through the superior and inferior cul-de-sac, and through t skin of the lid as also illustrated. Figure 2 shows the superficial distributi of the most important of these nerves and illustrates the necessary deman for nerve blocking.



A B

FIG 2 —A, areas of skin distribution for injecting, the supra-orbital and supra-trochle nerves, the lacrimal and zygomatic nerves, the infra-orbital nerve; and the infra-trochle nerve, B, corresponding regions of lymphatic drainage

Inhalation Anesthesia.—When inhalation anesthesia is used, the assi tance of a skillful anesthetist is necessary. Some surgical procedures ca be carried out with a local anesthesia plus nitrous oxide-oxygen ga Enucleations and eviscerations, especially on the aged, are such instance Chloroform is satisfactory for minor lacrimal surgery, for eviscerations an enucleations and for discissions in children. Venethene is especiall satisfactory as an adjunct to rectal anesthesia, and, when thus combine is the single most satisfactory form of general anesthesia. Only sma amounts are necessary, the patient recovers without nausea, and it ha a very high margin of safety. (Venethene and ether cannot be used i the presence of the actual cautery as they are both explosive.) It especially satisfactory, both to the patient as well as to the operator, fo cataract surgery, on a nervous individual, and also for the surgery o retinal separation. Extensive orbital surgery and the surgery of cartilag and of fascial grafts is readily carried out with this combination. A ju criticism of the ophthalmologist, relative to his use of anesthesia, is h insufficient use of general anesthesia, rather than a too frequent use of th method.

Intravenous Anesthesia.—Surgical procedures and especially intra-ocula surgery are commonly necessary upon very nervous individuals, and upo

the insane. Sodium amytal, intravenously, has been used, but not with great success. A sodium salt formerly dispensed under the trade name of Evipal has more recently been replaced almost wholly by pentothal sodium. The period of anesthesia with this can be continued for fifteen to twenty minutes and even longer without any harm to the patient. Full anesthesia is obtained with a prompt and uneventful recovery. It has been used for corneoscleral trephinings, for cataract extractions, for enucleation, and for other more or less minor surgical procedures.

Rectal Anesthesia.—Rectal anesthesia with avertin (tribromethanol) has proven very satisfactory. Routine cataract cases, many muscle cases, enucleations and eviscerations, and practically all plastic surgery, as well as a large percentage of cases for retinal surgery, are being operated under this anesthesia. The use of this anesthetic, however, is contraindicated in diseases of the hepatic or cardio-vascular renal systems. Children below ten and adults over seventy years of age are usually operated with some other form of anesthesia. The dosage is from 75 to 90 mg. per kilogram of body weight. As stated under inhalation anesthesia, venethene must be used in about 50 per cent of the cases as an adjunct. The effect of the anesthesia is enhanced by proper presurgical medication, though morphine should not be used for cataract cases. Usually the venethene is necessary for only a very short time, the patient thereafter continuing quiet and relaxed for the remainder of the operation. If venethene is not used, infiltration anesthesia and nerve blocking must be added. The postoperative recovery from avertin is ordinarily quite uneventful.

PREOPERATIVE AND POSTOPERATIVE PROCEDURES

Preoperative Procedures.—The preoperative care of an ophthalmological patient is as for any other branch of surgery extremely important Instances occur wherein immediate surgery must be done, regardless of the patient's general physical condition. With the exclusion of these, the time and place for surgery can be selected with deliberation. Cases with cardio-vascular-renal pathology should be at maximum compensation. In general, it is unwise to perform any intra-ocular surgery with blood-pressure above 180 mm. Hg., systolic; and 100 mm. Hg., diastolic. These are the top for safety. If medication (sedatives and vasodilators), rest in bed, and a controlled diet cannot reduce the blood-pressure below these points, then venesection is permissible, two to four hours prior to the surgery. A patient with prostatic hypertrophy can be safeguarded by the introduction of a retained catheter, until the patient may be permitted to stand for urination. Patients with emphysema and with asthma can be carried through safely, in many instances, by the judicious use of codein, of atropin, and by the position in bed; also steam inhalations are of assistance, especially postoperatively. The necessity for standardization of a diabetic, prior to surgery, is so important, that failure to do this is to be strongly criticized. If the patient has diabetes, one certainly must be sure that his diabetes is controlled before attempting any surgery; in fact all cataract cases, especially in older people, should have a blood sugar determination, even though the urine be sugar free. Postoperative catastrophies are frequent enough under the best of circumstances, and in diabetics the vascular

system is definitely impaired. It is especially necessary to safeguard the result in cataract cases.

A mouth filled with dental apical abscesses, and with extensive dental caries, should have these conditions remedied before any intra-ocular surgery is carried out. Postoperative, metastatic infections have resulted from the failure to correct this.

The bacteriological state of the conjunctival cul-de-sacs has been under consideration by various investigators. No one will attempt intra-ocular surgery in the presence of actual suppuration; still in the author's experience, the only cases which developed postoperative infections, following intra-ocular surgery, were instances wherein errors occurred in the preoperative bacteriological investigation of the cul-de-sacs. Chapman, Liev, Berens, and Curcio,[1] recently presented a most conclusive means of identifying *in vitro* pathogenic bacteria. With their technique, it seems that each case should have the benefit of such a determining procedure. A bromthymol blue agar, corrected to a pH of 6.8 showed an agreement between this culture medium and tests with hæmolysis, with coagulase, and with crystal violet agar with less than 10 per cent of errors. Further, a factor which minimizes even this small error is the known fact that in "pure" cultures of pathogenic strains, non-pathogenic variants appear soon after isolation. Routinely a conjunctival epithelial smear is taken, incubated upon brain broth, and after twenty-four hours of incubation if any organisms are present, the growth is transferred to a blood agar plate for the determination of hæmolysis. In general, surgery is contraindicated in the presence of any hæmolytic organism and is permissible only with the report of no growth, or in the presence of mild infestation of the Staphylococcus albus and of the Bacillus xerosis. All other microörganisms should disappear before surgery is done. This can be achieved rather readily, by the irrigation of the cul-de-sacs with a 1 to 10,000 solution of metaphen and the instillation of a 5 per cent collargol ointment. The eyes should be kept closed with an occlusive dressing for twenty-four hours, and after irrigation further bacteriological studies are made. This is continued daily until a satisfactory report has been made. The occlusion dressing is then continued until the patient is operated. Equally satisfactory is a 4 per cent aqueous solution of mercurochrome. This is successful for clearing up extensive staphylococcus infestation, and the occasional case wherein pneumococci are found. Optochin may be necessary, at times, for this infection. The instillation of 1 per cent silver nitrate with immediate neutralization before surgery is frequently used and is recommended.

The lacrimal sac should always be investigated. This is certainly necessary in the presence of positive conjunctival cultures. Frequently a sac, which appears normal at gross inspection, will harbor streptococci and pneumococci. Irrigations of the lacrimal sac under such circumstances will increase the bacterial flora of the conjunctival cul-de-sac to such a degree that one has no doubt of this statement. Ocular surgery, in the presence of an infected lacrimal sac must be postponed until this infection is corrected.

Under ordinary circumstances, the patient should be admitted the evening before the day of the operation, as sedatives that night and the following morning are of proven benefit. The patient comes to the operat-

[1] Journal of Bacteriology, vol. 33, May, 1937.

ing table, when under local anesthesia, composed and without apprehension. Preanesthetic medication is essential for a general anesthetic. Dehydration used prior to surgery in glaucoma and for retinal separation must be discontinued the day before the surgery. For this interval give fairly large amounts of fluid and of alkalies. The patient should come to the operating room with at least the lower bowel well cleansed by an enema. The casual use of cathartics, of high enemas, and of colonic irrigation, is to be condemned. Diet, in so far as the preoperative period is concerned, differs little from that for any other operation.

Postoperative Procedures.—Postoperative complications are often due to conditions which could have been prevented. The nausea and the vomiting of postoperative shock is sufficiently distressing without the occurrence of accidents which should not have occurred with proper postoperative nursing. In general, cataract cases should have a private nurse for the first twenty-four hours following the operation. Other operations, which were long or attended by extensive hæmorrhage, or which have been done in the presence of a poor physical condition preëxisting, also fall within the same class.

Postoperative nervous shock must be treated with the barbiturates, with amytal preparations, and with codein. Morphia causes postoperative vomiting, hence it is unwise to use this. Postoperative gastric distress and flatulence can be minimized by careful diet. For the first twenty-four hours following intra-ocular surgery, the diet should be only a 2 ounce mixture of fluids at two-hour intervals (eliminating iced liquids and milk preparations). For the following twenty-four hours, a very soft diet at *four-hour intervals is advisable. On the third postoperative day, the* patient may have the usual meat-free, soft diet, this increased as the patient's improvement continues. Many operations, other than cataract cases, can be started postoperatively with this second day diet as well, eliminating the first day procedure. Cathartics should not be given before the first dressing. In the surgery of retinal separation, catharsis may be delayed until the third postoperative day. In such instances it is wise to give an enema prior to the cathartic. The postoperative diet of a standardized diabetic should be continued in its caloric content, divided, however, into five portions, and if insulin is being used, the diet with its accompanying dose of insulin given in fifths for the first day and in fourths for the second day. On the third postoperative day, this detail is no longer necessary.

Under ordinary circumstances the average patient when convalescing from ophthalmological surgery is most comfortable in a dimly lighted room. The telephone usually should be disconnected. A postoperative rupture of the eyeball has occurred, following cataract surgery, in a patient who on the third day after the operation was startled by the sudden ringing of the telephone near his bed. It is equally distressing to the patient to have a flashlight thrown on to her face by a nurse (especially applicable with ward cases) who wants to find out if the patient is sleeping. Instances similar to this are wholly unnecessary, and unpardonable. Visitors are to be permitted as is best for the individual case, for in some instances it would be wisest to permit them.

Figure 3 shows the usual metal shield. This should have a gauze dressing beneath it. After the sutures have been removed and the patient is con-

valescing, the shield may be worn, as illustrated, for protection. Figures 4 and 5 show the classical Fuchs mask, to be used either as a single or as a double mask depending upon the conditions present in any given patient.

Fig 3.—Aluminum cup in place (Török and Grout.)

Cases of arterial hypertension with intra-ocular surgery must be as carefully controlled after the operation as before. The minimum level of the systolic and the diastolic blood-pressure need not be as low but should be kept down as much as possible with reasonable medication. The nitrites in $\frac{1}{100}$ grain doses three to four times daily, have helped frequently for the few days during which this is especially necessary, though they are prone to cause nausea. Sedatives, as sodium amytal, allonal, and the bromides are perhaps more valuable.

One must be constantly on guard because of the possibility of hypostatic pneumonia in the aged. It is necessary to change their position in bed rather frequently, at least hourly. Aged people lose strength rapidly when confined to bed for more than a few

Fig 4.—Single Fuchs mask. (Török and Grout.)

Fig. 5.—Double Fuchs mask. (Török and Grout.)

days; therefore, in cataract surgery, it is necessary to suture the conjunctival flap when one must get the patient out of bed at as early a

time as is safe for the eye. Supportive treatment must be used whenever indicated. The diabetic is to be checked by daily blood sugars. Postoperative hæmorrhages, especially into the anterior chamber are not uncommon in diabetics who get out of control. Postoperative flatus, with the patients who have been kept quiet, is not uncommon and often is distressing. Patients may complain of this more than from pain in the operated eye. The diet as outlined above, if adhered to, will minimize this in part. Elevation of the patient, from 15 to 30 degrees, on a back rest is advisable. A rectal tube may be necessary. Hot turpentine compresses over the abdominal wall have proven of benefit at times. Low enemas will expel much of it, but usually the greatest complaint occurs before the operator is able to use postoperative cathartics and enemas. Pituitary extract, hypodermically, may be used when the age and the condition of the individual, and the type of operation done, will permit. In general, it would certainly be unwise to use it following cataract surgery, and perhaps in the surgery for glaucoma and retinal separation.

Postoperative pain, in ocular surgery, is never a great problem. The onset of pain from twenty-four hours to four or five days after an operation is rather likely due to hæmorrhages into the anterior chamber or even to a sub-choroidal hæmorrhage. The sudden and abrupt onset of pain in a patient previously free of pain should always be investigated. In orbital and in bone surgery the pain which follows can be controlled rather well with morphia. The pain in muscle surgery can be minimized to a large extent by the consideration one pays to the muscles during the surgery. Tincture of camphorated opium for children, and codein for the older patients are usually adequate. The postoperative pain of glaucoma surgery and the usual postoperative pain of cataract surgery are fairly well controlled with the milder sedatives. Amytal and the barbiturates are sufficient. Codein is occasionally necessary. Morphine should never be used. Many of these patients complain of considerable pain in the back from the enforced quiet. Alcohol sponging can be done to alleviate this without moving the patient's head to any great extent. Various operators differ decidedly in the necessity for absolute quiet following cataract surgery. Some enforce it with sand bags applied to each side of the head and with tie sheets, and others are as inattentive to this as the first are meticulous in demanding the immobility. Every case is a law to itself, and must be treated individually. It is true, however, that the patients who are allowed a bit more freedom, complain the least of postoperative distress.

THE RÔLE OF THE ASSISTANT

In general surgery, the operating room assistant does not have the same importance as has the assistant in ophthalmic surgery. In hospital practice, the urinalysis, the blood sugar, the condition of the conjunctival cul-de-sacs, the careful scrutiny of the lacrimal-nasal ducts, the blood-pressure studies, the patient's dental condition, and a survey of his cardio-vascular-renal system, are requirements the responsibility for which should be assumed by the assistant. A proper routine, when instituted, will take care of this almost automatically. It should not be necessary for the operating room surgeon to interrogate his assistant as to each of these important points. The same thing applies for the routine of the postoperative care of patients.

Each class and type of case should have a routine postoperative outline for the information of the assistant and the nurse. This outline should be carried out in all instances under ordinary circumstances. In the operating room the assistant should oversee the preparation of the patient for the surgery, the selection of the instruments, their proper sterilization and should early in his career strive for a degree in operating efficiency which will make it possible for him to assist intelligently, to anticipate instrumentation, and to assist in preventing operating room complications which occasionally develop. It is unfortunate that many ophthalmic surgeons must operate with the assistance of untrained hospital residents and with even less well-trained nurses.

The position of the operator relative to the patient's head is individual with each surgeon. Some operators have developed an ambidexterity which enables them to work always from the right side of the patient. Many surgeons stand to the right slightly toward the top of the patient's head for surgery upon the left eye and at the top of the table for surgery upon the patient's right eye. With the exception of an iridectomy, most glaucoma surgery is done with the operator standing at the top of the table. With these positions thus outlined, for the operator, the assistant usually stands at a right angle from the operating surgeon, with his right and left hands close to the operator's right and left hands. Least confusion and most adept assistance develop under such an arrangement.

SURGICAL ASEPSIS—STERILIZATION

Cutting instruments, and very delicate forceps, can be sterilized in 75 per cent alcohol for thirty minutes or in one of the many patent formaldehyde preparations now on the market. Most of these have a phenol coefficient which is high and several of them make quite a point in claiming the absence of rust with instruments sterilized in their solutions. Fifty per cent phenol is a satisfactory agent for scissors, for punches, and chisels, and sharp calipers and dividers. After a half hour immersion in these, they are washed in alcohol and then in water. All other instruments, as well as all sutures not marketed in sterile sealed tubes, should be boiled for at least twenty minutes.

Sterilization of the field of operation according to the routine of many surgeons, is done in part by the nurse. The eyebrows are shaved for some operators; for others they are clipped, and for many the lashes are also clipped. Under many circumstances this may be necessary, but it hardly seems essential that it be done on all cases. In operating on the insane as it must be done in asylums, these precautions are indicated. In orbital surgery, they are absolutely necessary. In muscle surgery the clipping of the lashes is usually adequate. In cataract and glaucoma surgery the lashes should be clipped and while the eyebrow need not be shaven, under ordinary circumstances, it should be covered with several layers of wet gauze tucked firmly under the sterilized sheet or the sterile towel which has been wrapped about the patient's head. A satisfactory routine is to have the skin of the lids scrubbed with tincture of green soap, then washed with boric acid, and the cul-de-sacs copiously flushed with 1 to 10,000 of metaphen. This may be done one hour before the patient is to go to the operating room. The eye is then covered with a sterilized eye pad and this

retained in place with a light roller bandage. In the operating room the bandage is removed, the cul-de-sacs again flushed with metaphen, the skin of the lids further cleansed and dehydrated with benzine followed by alcohol, and then wiped carefully, including the line of lashes and the eyebrows, with a 3 per cent aqueous solution of picric acid. If the lashes have not been clipped before the patient came to the operating room, and it is thought necessary to do so, this should be done before the cul-de-sacs are irrigated. The blades of the scissors should be covered with sterile white vaseline to prevent the cut lashes from scattering about. After the patient has been draped, and the field of operation cleansed, the face can be covered with a perforated eye sheet, the perforation being sufficiently large to extend from the eyebrow to 2 cm. below the level of the normal palpebral fissure, and from 2 cm. beyond the external canthal angle to 1 cm. beyond the inner canthal angle. The hole will not be round but a small oval, long

Fig. 6 —Ring's mask applied (Török and Grout.)

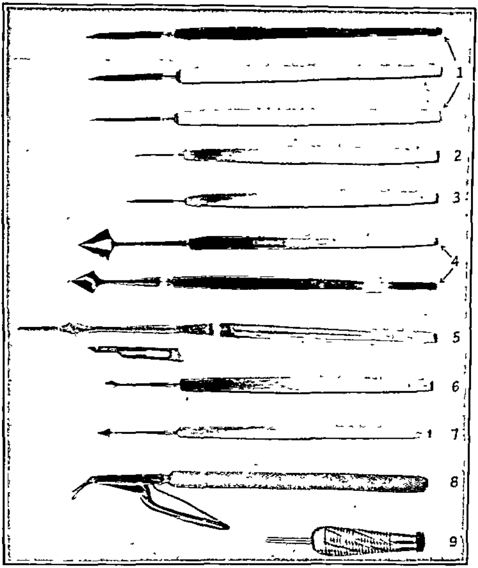
Fig. 7 —Pressure bandage in place. This is to be reënforced by oblique strips of adhesive which pass over the forehead around to the occiput (Courtesy of The Blakiston Company.)

axis horizontal. These eye sheets may be made of white operating room cotton; if, however, they are tinted a dull green or even a light gray, they are more restful to the eye of the operator and are equally satisfactory when moving pictures are to be taken.

Postoperative dressings depend very much upon the type of operation which has been done, and are properly covered under the relevant subsections. In general, however, the Barraquer dressing, a thin film of saline soaked cotton, covering the closed palpebral fissure and this covered with a pad of dry cotton, applies very nicely to most surgery procedures. As this dressing dries it conforms to the convexity of the lids, holding them closed and splinting them satisfactorily. Eye pads, bandages, metal plates and/or masks may be placed on top of the dressings according to the desire and the practice of the individual surgeon. Figure 6 shows a Ring's mask properly applied, and Figure 7 a pressure dressing.

INSTRUMENTS

The instruments which are used in surgery of the eye are so great in number that it is impossible to portray all of them. Each operator develops personal likes for scissors and for forceps of various kinds. The standard instruments, however, are illustrated in Figures 8 to 16. Many new instruments are being added almost daily. Those illustrated are all well known.



FIGS 8 to 16, inclusive Ophthalmological instruments See text for the instruments listed.

FIG. 8 —1, von Graefe cataract knife, of three sizes and widths made with a metal handle and rather recently Kirby's modification with a cylindrical handle. 2, The Ziegler knife needle, this is made in several sizes. 3, The Wheeler knife needle. 4, The keratome, with its triangular shaped blade, is made either angular or curved, with various shaped blades; and under various circumstances the back of the blade is curved or made flat. 5, The scalpel best used, is supplied by the patent blades and the patent handle of various surgical supply houses. 6, Sharp corneal splitter for glaucoma surgery. 7, Blunt corneal splitter for glaucoma surgery, Elliot's 8, Scleral punch. 9, Trephine blade and handle, Elliot's.

The above instruments should be sterilized in alcohol, in phenol, or in one of the patented non-rust producing solutions already mentioned.

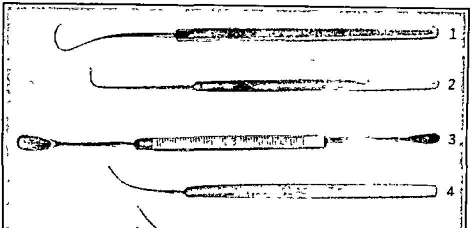


FIG. 9.—1, Large strabismus hook 2, Small strabismus hook 3, Doubled end broad spatula for cataract surgery. 4 and 5, Single and double end iris spatula 6, A cyclodialysis spatula, Elschnig's. 7, Small curet for chalazion and similar surgery 8, Large curet for chalazion and similar surgery. 9, Large curet for evisceration. 10, A standard lens loop 11, Peter's hook for cataract extraction

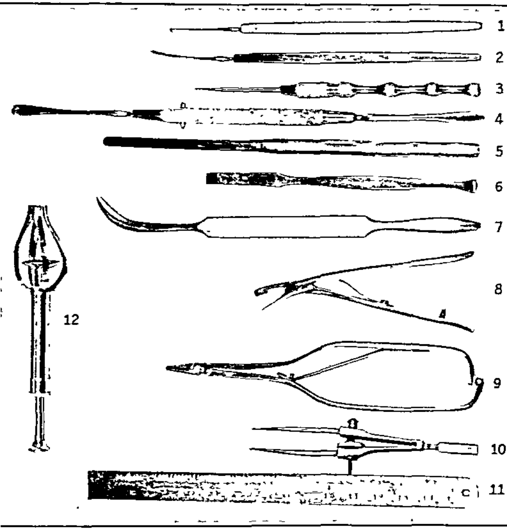


FIG 10—1 Tyrell hook for iris surgery 2 Spoon for expressing lens fragments 3, Cross handle and burr for corneal ulceration and for the removal of foreign bodies. 4, Sharp and blunt periosteal elevator 5, Chisel 6, Chisel 7, Periosteal elevator 8, Author's needle holder for conjunctival and cataract surgery 9, Standard needle holder. 10, Dividers for retinal separation surgery. 11, Mm metal rule. 12, Mules' sphere introducer.

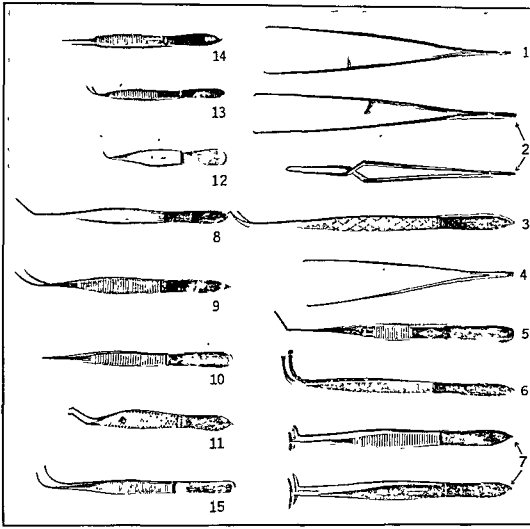


FIG 11 —1, Toothed fixation forceps 2, Fixation forceps with lock, and with spring 3, Tissue forceps without teeth 4, Tissue forceps with teeth Both of these are necessary at times for various dissections 5, Standard muscle advancement forceps 6, Peter s cataract extraction forceps, which when the blades are closed, can be used as an expression hook 7, Scleral fixation forceps It is not uncommon to find great difficulty in fixation of the globe and this type of forceps has proved satisfactory 8, 9, 10, 11, are the standard capsule forceps in use by the various operators the Kalt the Arruga, the Elschnig and the Verhoeff 12, Fuchs' capsule forceps 13, Fuchs' toothed iris forceps 14, Conjunctival forceps 15, Smooth capsule forceps

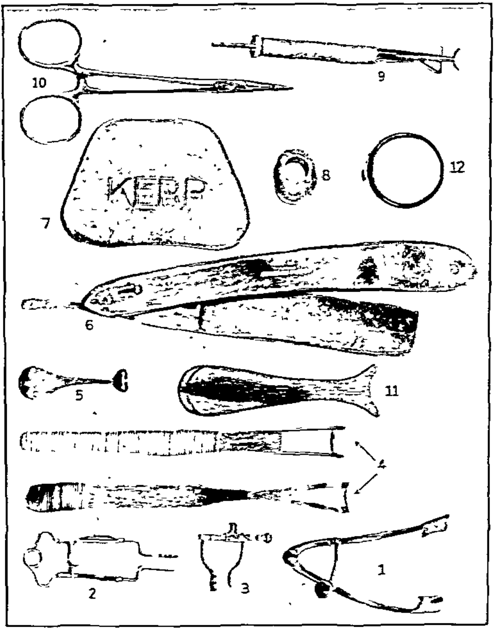


FIG 12—1 A lid speculum. There are many acceptable types of these some of which are designed for various operations Quist has a very satisfactory one for retinal separation surgery. 2, Standard lacrimal sac speculum. 3, Small self-retaining retractors. 4, Two of many varieties of lid elevators 5 Small lid retractor very satisfactory for cataract surgery. The handling of the lid by the assistant is, next to the operator's own manual dexterity, the most important thing during the operation 6, The author's model of skin graft razor, hollow-ground and flat on the opposite surface. 7, An example of a satisfactory preparation for making molds for socket reconstruction, and for other grafts It is known as dental stent. 8, Silver conformer for socket and conjunctival plastics. 9, Peter's modification of the Bishop tendon tucker 10, Mosquito forceps or clamp 11 Bone lid plate 12, Testing drum.

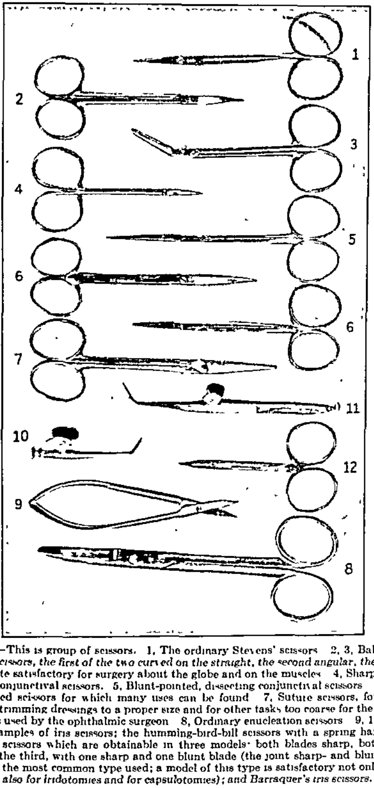


Fig. 13 —This is group of scissors. 1, The ordinary Stevens' scissors 2, 3, Ball-pointed *dissecting scissors, the first of the two curved on the straight, the second angular, the latter of* these is quite satisfactory for surgery about the globe and on the muscles 4, Sharp-pointed dissecting conjunctival scissors. 5, Blunt-pointed, dissecting conjunctival scissors 6, Large, sharp-pointed scissors for which many uses can be found 7, Suture scissors, for cutting catgut, for trimming dressings to a proper size and for other tasks too coarse for the ordinary fine scissors used by the ophthalmic surgeon 8, Ordinary enucleation scissors 9, 10, 11, 12, Popular examples of iris scissors; the humming-bird-bill scissors with a spring handle, the de Wecker scissors which are obtainable in three models: both blades sharp, both blades blunt, and the third, with one sharp and one blunt blade (the joint sharp- and blunt-bladed scissors are the most common type used; a model of this type is satisfactory not only for iris *surgery but also for iridotomies and for capsulotomies); and Barraquer's iris scissors.*

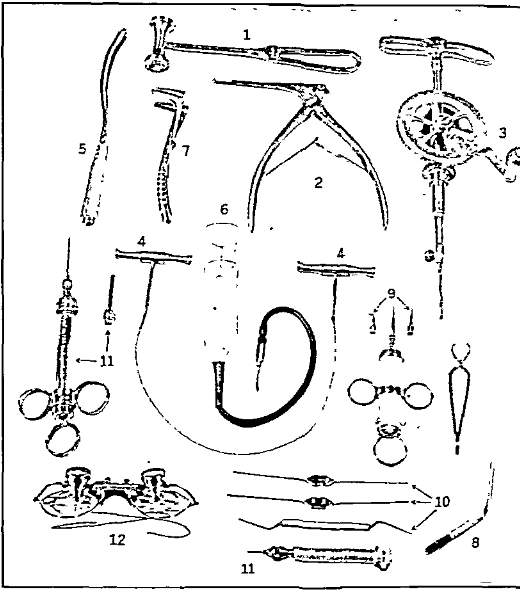


FIG 14 —These are instruments rather necessary at times but not commonly used. 1, A mallet with a soft metal head 2 A punch for dacryocystorhinostomies 3, A small drill and bit the drill of such a size that the ordinary Gigli saw can be readily threaded through the hole 4. Gigli saw with draw handles Hemostats may be substituted for these handles quite as satisfactorily 5, A cartilage graft chisel, hollow ground, concave-convex and of several different widths 6 Fox type of anterior chamber irrigator. The fluid flow is by gravity and it seems that the flat tip with this easily controlled hydrostatic force behind it is much more satisfactory than are the various bulb and hand pressure irrigators The tip can be used as an iris spatula and it is so thin that it does not appreciably elevate the lips of a corneo-scleral incision during the irrigation It is rather essential that a tip of this type be cleansed with a wire before use, so that the surgeon is assured of a free-flowing stream of the solution. 7, 8, are a standard nasal speculum, and the nasal forceps necessary for lacrimal sac surgery. 9, is a very satisfactory lacrimal syringe with needles which lock on the barrel. 10, A small and delicate model of the Ziegler lacrimal duct dilator, Ordinary lacrimal probes. 11, A lock syringe for local anesthesia. A syringe of this type is quite necessary for infiltration anesthesia in the presence of scar The needles should be of a fine gauge from 26 to 28 and should be threaded so they may lock upon the syringe. 12, Zeiss binocular loupe.

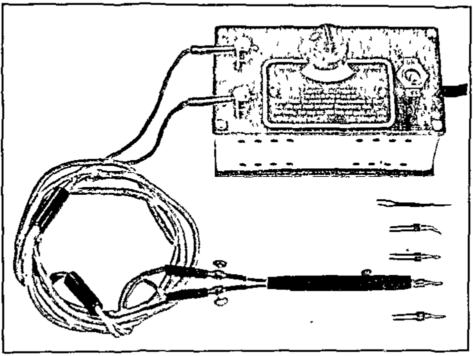


FIG 15 —Ziegler's electro-cautery outfit with necessary cautery tips

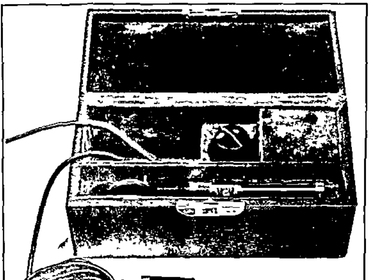


FIG. 16 —The author's combination ophthalmoscope and transilluminator for retinal separation surgery. Any similar model is equally satisfactory.

CHAPTER II

GENERAL PATHOLOGY OF THE ORBIT. PATHOGENESIS OF EXOPHTHALMOS. ACUTE AND CHRONIC INFLAMMATORY PROCESSES. NEOPLASMS, AND NEW GROWTHS. SURGERY OF EXOPHTHALMOS. FRACTURES OF THE BONES OF THE ORBIT. ORBITOTOMY AND ORBITAL WALL RESECTION

PATHOLOGICAL conditions of the orbit involve or include conditions which arise primarily within the orbit as some neoplasms; conditions secondary to some general systemic conditions as gummata, and as tuberculosis of the bones of the orbit and the exophthalmos from myelogenous leukemia, the pathology of the Schüller-Christian syndrome; by extension from contiguous tissues as the inflammatory and suppurative retrobulbar processes from the soft tissues of the face and from the nasal accessory sinuses; and last, orbital conditions of diagnostic value, as the proptosis of cavernous sinus thrombosis, the exophthalmos of acute thyrotoxicosis, and the orbital signs and symptoms of arteriovenous aneurysm and pulsating exophthalmos. Traumatisms of the orbit are not by themselves quite a separate class, in that they may exhibit the signs of any of the above subdivisions.

A classification of orbital diseases is rather difficult, for even the subdivision of acute and chronic phases is not clean cut. Exophthalmos and proptosis are present in some and not in others, and even in the same disease may be absent or even transient. Eagleton called attention to this in discussing cavernous sinus thrombosis; the exophthalmos of cavernous sinus thrombosis which extends from a lateral sinus thrombosis is often so decidedly transient, that the diagnosis may be missed rather frequently. An anatomical basis for any classification must be followed instead of one based upon pathology.

UNILATERAL EXOPHTHALMOS

Unilateral and bilateral exophthalmos are a common symptom in orbital pathology. Unilateral exophthalmos is not of necessity similar etiologically to the bilateral conditions. There is no doubt that many conditions of unilateral exophthalmos may be simply incomplete in terms of bilateral involvement. Of this, exophthalmic goiter is perhaps the outstanding example It is just as true, however, that many different conditions have as a primary characteristic, a unilateral displacement of the eyeball. Involvement of the opposite side in such cases would be secondary and not consequent. Orbital neurofibromatosis is a satisfactory illustration of this variety. It seems, therefore, that unilateral exophthalmos may be considered as a definite clinical entity. A classification of unilateral exophthalmos, from the standpoint of etiology, will include several subdivisions, anatomical, traumatic, those of inflammatory origin, diseases of the blood and the lymph and the hæmatopoietic systems, and space taking lesions.

Anatomical.

1. High degrees of unilateral myopia. Staphylomata.
2. Defects in the vault of the orbit. Meningocele and meningo-encephalocele.
3. Exophthalmos with ocular hypertension.
4. Exophthalmos with arterial hypertension.
5. Pseudo-exophthalmos from retraction of the lids. Pseudo-Graefe syndrome.
6. Intermittent exophthalmos.
7. Pituitary gland pathology.
8. Exophthalmos from cervical sympathetic irritation.
9. Exophthalmos, unilateral, with toxic goiter.

Traumatic.

1. Fracture of the orbit, orbital emphysema (from fracture into nasal accessory sinuses), retrobulbar hæmorrhage.
2. Laceration and rupture of the extra-ocular muscles.
3. Traumatic evulsion of the globe.
4. Birth trauma, intra-cranial internal carotid aneurysm.
5. Foreign body in the orbit.
6. Pulsating exophthalmos, arterio-venous aneurysm.
7. Retrobulbar hæmorrhage from whooping cough.

Inflammatory. These must be either acute, subacute, or chronic. Their order, herewith, is roughly the sequence for their chronicity.

1. Retrobulbar cellulitis.
2. Retrobulbar phlegmon.
3. Retrobulbar abscess.
4. Thrombophlebitis of the orbital veins.
5. Cavernous sinus thrombosis.
6. Erysipelas.
7. Tenonitis (at times suppurative).
8. Periostitis. Luetic and tuberculous, but not to include gummata. Pseudo-tumor. Lacrimal sac pathology. Tuberculoma.
9. Orbital mucocele, pyocele, cholesteoma.
10. Orbital exostosis.
11. Paget's diseases, with hyperostosis.
12. Actinomycosis. Trichinosis. Mycotic pseudo-tumor.
13. Xanthomatosis. Schüller-Christian syndrome.
14. Ocular Myosites.

Diseases of the Blood and the Lymph and the Hæmatopoietic System.

1. Rickets. Scurvy. Hæmophilia.
2. Lymphosarcoma. (Piney; lymphoblastic.)
3. Acute and chronic lymphatic leukemia. Lymphoendothelioma. Mikulicz's disease (Wolff; malignant lymphoma).
4. Hodgkin's disease. (A sclerosing type of lymphoma.)
5. Myeloblastoma; chloroma. (A bone marrow picture.)
6. Myelogenous leukemia. (Premyelocytes and myelocytes.)

Space Taking Lesions. The order here is roughly, as well, the degree of malignancy, as seen and reported by many different observers.

1. Dermoid cyst. Sebaceous cyst. Gumma.
2. Fibroma.
3. Neurofibroma.

Space Taking Lesions.—(Continued.)

4. Lipoma.
5. Osteoma. Osteofibroma. Bone cyst.
6. Myxoma.
7. Chondroma and chondromyxoma.
8. Cylindroma of lacrimal gland.
9. Psammoma.
10. Adamantinoma.
11. Lymphangioma and hemangioma.
12. Plasmoma.
13. Meningioma or endothelioma.
14. Rhabdomyoma.
15. Glial tissue tumors as neuroma, neuroblastoma, retinoblastoma, spongioblastoma polare.
16. Sphenoidal ridge tumors.
17. Carcinoma.
18. Sarcoma. Mixed cell tumors. Intra-ocular sarcoma.
19. Malignancy from the nasal accessory sinuses. These to include carcinoma, sarcoma, psammoma, chondroma, and myxoma.
20. Metastatic malignancy as osteogenetic sarcoma, adenocarcinoma, hypernephroma, etc.
21. Unilateral exophthalmos from brain tumor—without orbital extension; mechanical causes, as edema; and with extension into the orbit. Two per cent of all unilateral exophthalmos is due to brain tumor.

BILATERAL EXOPHTHALMOS

The classification of bilateral exophthalmos is much more simple.

Anatomical.

1. Defects in the vault of the orbit, very rare.
2. Bilateral exophthalmos from pituitary gland pathology.
3. Bilateral exophthalmos from toxic goiter.

Traumatic.

1. Gunshot wounds and perforating wounds involving both orbits.
2. Birth traumata, the bilateral extension from arterio-venous aneurysms and perhaps retrobulbar hæmorrhages.

Inflammatory.

1. Bilateral retrobulbar infections and suppurations.
2. Thrombophlebitis of the orbital veins.
3. Cavernous sinus thrombosis.
4. Erysipelas.
5. Xanthomatosis, as the Schüller-Christian syndrome.

Diseases of the Blood and the Lymph and the Hæmatopoietic Systems.

1. Rickets.
2. Scurvy.
3. Hæmophilia.

The symptomatology of the lymph and the hæmatopoietic systems is essentially unilateral; and in the Space Taking Lesions, unilaterality is the outstanding characteristic.

Conditions of both unilateral and bilateral exophthalmos are of surgical interest. Defects in the vault of the orbit may be present and show no

exophthalmos. Dehiscences in the roof of the orbit are rather common and are connected with the normal suture lines. The orbital roof of people of advanced years is usually thin, and may show similar dehiscences from senile atrophy of the bone. This is to be remembered in surgery of the orbit—to prevent perforation through the orbit and opening into the extradural space. Meningocele, meningo-encephalocele, and encephalocystocele, have all been reported as causing exophthalmos, because of such congenital anatomical defects. Safranck[1] reported one with recovery following surgical treatment. Edson and others have corrected similar cases with a transfrontal approach and with bone grafts to the roof of the orbit. A roentgen-ray examination will be sufficient for the diagnosis of such instances. Most of them enter the orbit through the medial wall. Unilateral exophthalmos is occasionally seen with arterial hypertension and *with unilateral ocular hypertension*, the exophthalmos in both instances being unilateral, and without any other orbital cause for the proptosis. One such case of Peter's was operated by a transfrontal route to the anterior fossa, the removal of the orbital roof and a thorough exploration of the orbital contents for any possible pathology. None whatsoever was found, except for possible increase in the blood supply of the orbital fat. Exophthalmos with arterial hypertension can be explained upon the basis of orbital vessel varicosities. Pseudo-exophthalmos is seen not uncommonly in various cranial nerve disturbances. The resemblance to exophthalmos results from a widening of the palpebral fissure due to retraction of the lids. At times it seems quite pronounced. Seventh cranial nerve paralysis, when present for a long time, illustrates this most frequently. Pituitary gland pathology is usually connected with unilateral as well as bilateral exophthalmos. There may be no roentgen-ray differences in the optic foramen nor are ocular motor disturbances necessarily present. The condition seems to be due to a retrobulbar venous stasis. Naffziger[2] states that this is most prominent with the eosinophilic form of adenoma of the pituitary gland. Unilateral exophthalmos from toxic thyroid pathology is most interesting. The author has no explanation to offer for the unilateral development of this in some instances while in others it is essentially bilateral. This observation has been made however, by Plummer.[3] Malignant (paradoxical) exophthalmos is rather likely unilateral, or if not unilateral it will affect the eyes unequally. From a surgical standpoint, *malignant exophthalmos, especially that variety which develops following* thyroid gland surgery, is a serious condition and most difficult to combat. The exophthalmos which occurs with thyroid pathology when the basal metabolic-rate is within the normal limits, is spoken of as paradoxical exophthalmos by Zimmerman,[4] and he rightly considers this as the more severe of the two forms, that is contrasting the exophthalmos with a high basal metabolic-rate with that of a low basal metabolic-rate. The exophthalmos develops following a thyroidectomy and has with it a hypothyroid state now *substituted for the former hyperthyroid state. It seems as if the* thyroidectomy which had been done was so done unwisely—that the primary condition was one of thyroiditis rather than one of toxic hyper-

[1] Ztschr f. Hals-, Nasen- u Ohrenhlk., Berlin, 3, 560, No 1, 1922.
[2] Arch Ophth., vol. 9, March, 1933.
[3] Trans. Am Acad Ophth and Otolaryngol, 1934.
[4] Am Jour. Med Sc., 178, 92, July, 1929.

thyroidism. As yet we are not clear as to the rôle which the pituitary may play in the development of malignant paradoxical exophthalmos. It could be not inconsequential. The surgery of this (see pages 39 and 98) should consider the following: median tarsorrhaphy and canthoplasty, the Shugrue decompression of the orbit, and a transfrontal decompression of the orbit.

This surgery, whatever is done, must be instituted, if possible, before *corneal ulceration has occurred. Simple conjunctival edema is not a* demand for radical surgery, other factors being equal. The extent of the exophthalmos, the rapidity of its development, and any dissimilarity in degree between the two eyes, are far more significant in deciding when surgery should be carried out. Plummer and Wilder feel that the exophthalmos with a low metabolic-rate may be in part an uncontrolled function of the entire lobe of the pituitary. Other possibilities are based upon the two product hypothesis of Plummer, that an abnormal product continues to act after the output of the normal product, thyroxin, has been curtailed. The edematous contents of the orbit in this variety of exophthalmos are comparable in some respects to localized subcutaneous areas of mucinous edema which are found in rare cases of exophthalmic goiter, particularly after thyroidectomy. The secondary glaucoma, which not uncommonly develops in these cases of post-thyroidectomy exophthalmos, is a positive demand for early operation by some type of orbital decompression. The orbital venous stasis, transmitted to the bulbar vortex veins, is probably the cause for the glaucoma. This type of ocular hypertension has not responded to any type of filtering cicatrix operation up to the time of this writing.

As a recapitulation, in regard to malignant exophthalmos the following two factors are repeated here in abstract. One, the type of case wherein malignant exophthalmos may be expected. The first of two possibilities is that wherein the ophthalmic syndrome seems to dominate the thyrotoxicosis as manifested by sweating, tachycardia, loss of weight; and cases which may have as a dominant ophthalmic syndrome a high degree of exophthalmos, lagging of the upper lid, loss of convergence, and retraction of the upper lid. The second type of thyrotoxicosis wherein malignant exophthalmos might be expected to develop is the case with high exophthalmos but with lowered basal metabolic-rate under thyroid extract and iodine therapy. These two types, clinically, are different one from the other. Each of the two, however, seem to predispose to late malignant paradoxical exophthalmos.

A recapitulation of non-surgical therapy in its relationship to this late type of exophthalmos is the second factor of importance. We are certain *that not a disease of the thyroid gland itself but metabolic disturbances* resulting from the loss of the thyroid gland are responsible for the exophthalmos. Roentgen-ray therapy to the pituitary, the use of estrogenic substances, and the large doses of thyroid extract which are tolerated in these conditions all suggest a disturbance in generalized internal secretion, perhaps the result of the thyroid deficiency. It is probable that the anterior lobe of the pituitary is largely responsible as a lawless and now unrestricted hormone bearing gland.

Rudemann (personal communication, September, 1938) feels that these cases of post-thyroidectomy malignant exophthalmos are due to a general-

ized polyglandular upset, as the result of the thyroid extirpation, and that they should not have had this operation performed. He recommends huge doses of thyroid extract, up to 20 grains daily. Rudemann also calls our attention to certain findings which seem to indicate failure from any type of orbital decompression. Edema of the lower conjunctival cul-de-sac, and very late development of the exophthalmos are two points of special interest. He has had very satisfactory results in 5 consecutive cases, having saved the eye in each instance by means of rubber tube drains passed subconjunctivally through the inferior cul-de-sac below the level of the inferior rectus. An incision is made in the conjunctiva at the inner and the outer canthi, and the tube passed from one to the other. This is formed of a small rubber catheter, and that portion which lies beneath the conjunctiva is perforated on its convex and concave curves with many very small cleanly punched-out holes. The ends of the tube lie outside the canthal angles.

Smelser[1] studied 6 cases of exophthalmos from the standpoint of their orbital contents. Biopsies were made in each instance and in each case there was an edematous infiltration of the muscles and the fat, accompanied by a cellular invasion which was limited largely to the perivascular lymph spaces. Most of the muscle fibers were structurally normal though in 2 instances there seemed to be some hypertrophy of the ocular muscles themselves. Smelser felt that an increase in the retrobulbar tissue was the apparent cause of the immediate exophthalmos, and that the etiology of exophthalmos could be postulated upon two bases, one morphological and the other functional in character. Morphologically, one must consider an increase in the orbital fat, orbital edema, and an increase in size in the extra-ocular muscles. The functional possibilities are the effects of drugs, of hormones, of toxins, of venous dilation, or a pure experimental electrical stimulation of the contents of the orbit. In his experimental work, thyroidectomized guinea-pigs were injected with anterior pituitary extract until an exophthalmos developed. This exophthalmos was not modified by preliminary cervical sympathectomy. In each instance the orbital fat was increased 100 per cent and the extra-ocular muscle 20 per cent, both n weight. Figure 17 illustrates bilateral proptosis but with a marked difference in the degree bilaterally present Figure 17, *E* illustrates a unilateral exophthalmos with an acute thyrotoxicosis wherein there is no manifest bilaterality. It seems as if the unilateral forms of exophthalmos are more commonly complicated by the ocular motor palsies. Repeatedly cases are seen wherein the principal complaint is that of diplopia, and in two instances the underlying cause for the exophthalmos had not been diagnosed.

In malignant progressive exophthalmos, surgery is essential to save the cornea; in spite of that it is not uncommon to have corneal ulceration result and continue to perforation of the globe with ultimate blindness.

The exophthalmos of thyroid disturbances must, from a surgical standpoint—that is ophthalmological—be divided into the exophthalmos of an acute toxic goiter and that paradoxical form of exophthalmos which follows only after the thyroid extirpation and which so frequently goes on to a truly malignant exophthalmos. There is an indefinite intermediate form, also, which starts with an exophthalmos of acute thyroid toxicosis, even

[1] Assn. for Research in Oph. 8th Scientific Meeting, July 8, 1937, Atlantic City, N. J.

when of a relatively low degree of severity, and which continues to advance following the thyroid extirpation for a small amount of further protrusion. Then it halts in its course and remains stationary.

Figure 18 *a* and *b* are illustrations of such a situation. The basal metabolism rate was plus 27 prior to her subtotal thyroid extirpation. The general symptoms which she had seemed to indicate that the thyroid surgery planned was a proper procedure. Following the surgery, however, the exophthalmos continued to advance for a short period, and thereafter

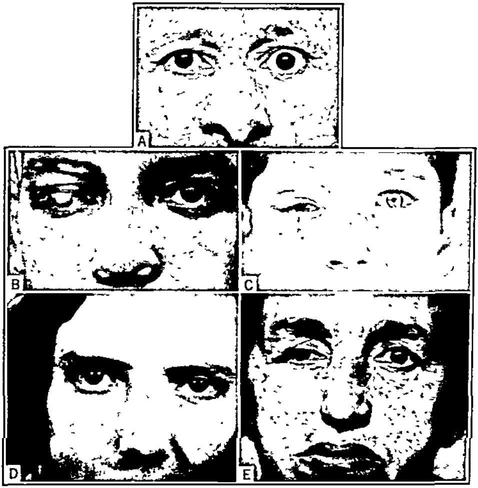


FIG 17.—*A*, bilateral unequal thyrotoxicosis exophthalmos; *B*, unilateral exophthalmos from evulsion of the optic nerve, *C*, unilateral exophthalmos from an acute retrobulbar phlegmon, *D*, pseudo-exophthalmos from an old unilateral facial paralysis; *E*, unilateral exophthalmos from thyrotoxicosis.

remained stationary for a year. There are no other symptoms of hypothyroidism. The Shugrue orbital decompression which was carried out in her case was purely for cosmetic reasons and not because of progress or advance in the condition.

Malignant exophthalmos, as such, is frequently a tragic affair and demands surgical procedures and medical therapy which frequently must be heroic in extent. The treatment of this latter type is generally quite different from the former two.

The surgery for the first of the two main subdivisions is always because of the cosmetic blemish, *i. e.*, the high degree of exophthalmos present. Many of these cases have suffused conjunctivæ, a mild to moderate degree of lagophthalmos, especially during sleep, and a chronic conjunctivitis from one, the other, or both. Disturbances in convergence as well as of the other extra-ocular muscles may be present. Figure 19 shows such a situation. She has a complete paralysis of the superior rectus muscle. Naturally, when the symptoms just mentioned are present to any appreciable amount, the surgery anticipated becomes almost obligatory. The patient shown in Figure 18 had no symptoms whatsoever to disturb her seriously except the appearance of the case, and mild lagophthalmos when sleeping. On the other hand the patient seen in Figure 20 had conjunctival edema, photophobia, tremendous engorgement of the superficial and deep conjunctival blood muscles, loss of convergence, and was incapacitated for work. The exophthalmos itself, in the latter of the two cases, was no more marked in extent. The presence or absence of the other additional changes does not depend wholly upon the degree of exophthalmos. His right orbit was decompressed with a transfrontal approach, and the left by means of a Shugrue technique. The end results are remarkably similar.

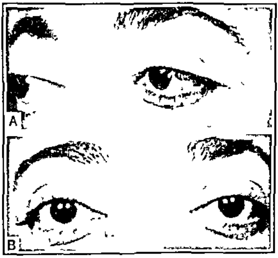


FIG 18.—Stationary exophthalmos before and after bilateral subzygomatic decompression

Unilateral exophthalmos from thyroid pathology is not especially uncommon. Actually the case probably has a bilateral exophthalmos with the protrusion more marked on one side than on the other. Practically these cases are less severe in their complications, but when they develop a true malignant exophthalmos it is serious. In two such instances, the one eye with the higher exophthalmos was lost through corneal destruction, ending in phthisis bulbi.

Stationary exophthalmos of a non-malignant character and without conjunctival edema is probably the mildest situation to handle. Axenfeld's lagophthalmos suture (which see) has been most satisfactory in a fair percentage of such instances. The surgery is simple and the results are good. It is not indicated, however, if the patient shows any great amount of upper lid retraction.

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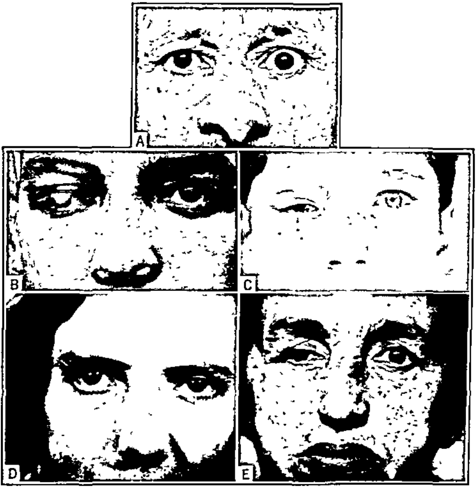

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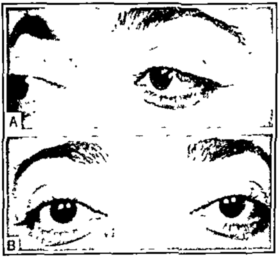

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Stationary exophthalmos, with a high degree of retraction of the upper lid, is better handled by the levator recession presented herein by Goldstein.

Occasionally cases present themselves with a long standing unilateral post-thyroidectomy exophthalmos, wherein the major lid defect lies in the lower lid. One can speak of it as a retraction from long standing spasm of the lower lid. In these cases the surgery is relatively simple. Figure 21 is such an instance. The angle tarsorrhaphy of Elschnig will lift the lower lid without displacing the upper lid too markedly, and at the same time it will shorten the palpebral fissures the desired amount. When utilizing this

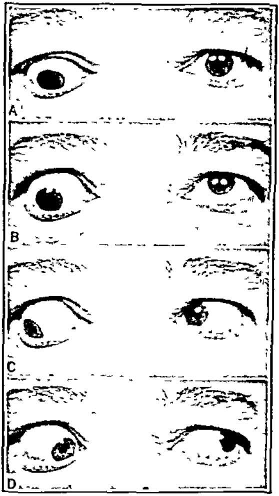


Fig 19 —Postoperative former thyrotoxicosis, unilateral oculomotor palsies. (*Courtesy of* Dr J. S. Shipman)

procedure, however, for exophthalmos, there is an additional step which should be taken. After the lid, at the external canthal angle, is split and the tongue of tarsus formed for transplantation, one should introduce a blunt-tipped scissors into the external canthal angle below the external canthal ligament, and make a horizontal cut through the entire length of the septum orbitale immediately beneath the lower tarsal plate. This sectioning of the unstriped muscle in the septum orbitale and with it the elastic fibers which are enmeshed within this muscle permit better correction and a nicer healing.

The severer forms of exophthalmos, with advancing protrusion, with edema of the conjunctiva, and with an exposed cornea need medical attention as well as surgery. Large doses of thyroid extract are often most valuable. Minor surgical procedure, such as median tarsorrhaphy, pressure

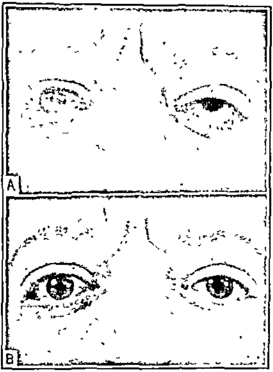


FIG. 20.—Exophthalmos former thyrotoxicosis O S following subzygomatic decompression, O D following a transfrontal decompression

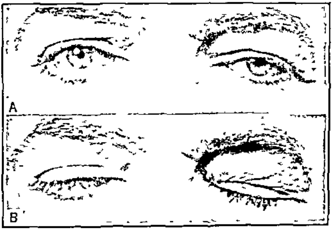


FIG. 21.—Unilateral old post-thyrotoxicosis exophthalmos with retraction of the right lower lid.

dressings, angle tarsorrhaphy, levator recession, etc., are all of no avail. Protective dressings are simply ameliorative and will not stop the progress of the condition nor save the cornea from exposure, ulceration and slough.

To recapitulate, the surgical correction for a thyrotoxicosis exophthalmos

seems to depend upon the type of exophthalmos present, that is whether it is stationary or paradoxical and malignant in type. In addition, the presence of other accompanying changes may indicate the grade of severity of the exophthalmos, as well as the underlying pathology causing the exophthalmos. The degree of exophthalmos present does not control the severity of these additional complications though a definite relationship is present.

The traumatisms which cause unilateral exophthalmos are neither unusual nor uncommon. A history of trauma, emphysema, exophthalmos, and of impaired ocular motility and the roentgen-rays findings is sufficient for a correct diagnosis in all cases. One must not be misled, however, by a history of a slight degree in the causative trauma. Extensive fractures have followed relative minor accidents, and reversely, quite severe traumata have frequently resulted in but little bone pathology. Evulsion of the optic nerve and exophthalmos from lacerations of the extra-ocular muscle occur from penetrating wounds (Fig. 17, *B*). The crepitus and the emphysema which accompany these cases indicate a compounded orbital fracture into the nose or into one of the nasal accessory sinuses. The orbital hæmorrhage which occurs is probably the greatest factor in the immediate exophthalmos.

Birth traumata can be most serious. The injuries fortunately are usually temporary but occasionally they remain permanent. The cranial bones of the vault, when subjected to various different forms of injury, as contusions, penetrating wounds, and even crushing injuries, react with fracture lines which follow patterns approximately common for all similar injuries. Holloway as well as various anatomists, demonstrated this. This is simplified, decidedly, it seems, when considering orbital fractures. The heavy wedge of the zygomatic arch, with the upper outer angle curve of the frontal arch, ordinarily prevents injury to the orbital surface of the greater wing of the sphenoid, unless they are themselves fractured. If they are fractured, the sphenoid must be injured as well. The floor of the orbit is a rather thin partition separating the orbit from the antrum, and continuing medially with the os planum of the ethmoid (bone structures similar in density and in structure), and is rather readily fractured from direct blows to the face and to the region of the orbit. The medial wall, at the apex of the orbit, may be included in these fracture lines. In such instances the fracture is almost certain to continue into the bones at the base of the skull, perhaps into the temporal bone, and when through the sphenoid, into the basilar process of the occipital bone.

Pulsating exophthalmos, that is arterio-venous aneurysms, either carotid-jugular, or carotid-cavernous sinus, has a history of injury preceding the exophthalmos. The typical bruit is present, fundus changes are not uncommon, and the bruit, the exophthalmos, and the pulsations can be modified by temporary pressure over the carotid in the neck. The real problem, in all of these vascular cases, is the differentiation of an orbital from an intra-cranial aneurysm. Moller[1] studied the records of 555 cases of aneurysms of the large cerebral vessels. Choked disk was not found in any of them. Ocular motor paralyses were common, bulbar protrusion was very rare, and pulsation of the eyeball was never seen in the simple (not arterio-venous) variety. Also this form was slightly more common in the female. The classical signs and symptoms of the arterio-venous type

[1] Klin. Monatsbl. f. Augenhlk., 66, 909, Stuttgart, June, 1921.

include, in addition to the above, a history of the injury, pulsating exophthalmos, and pounding or ringing sensations in the head, *i. e.*, the bruit.

The surgery of these cases is not a problem for the ophthalmologist. Dorrance and Loudenslager[1] subdivided ligation of the intern l carotid and ligation of the common carotid into two rather definite divisions in so far as indications and contraindications are concerned. Their conclusions were as follows: Ligation of the internal carotid in the presence of an arteriovenous fistula in the cavernous sinus is contraindicated for the following reasons: (1) It has been followed by a high incidence of hemiplegias. (2) Its ligation completely cuts off any blood volumes which may be getting past the fistula and reaching the brain. (3) It creates an area of low resistance at the site of the fistula and thereby stimulates a reversal of flow in the segment of vessel distal to the fistula. Such reversal of flow, by draining

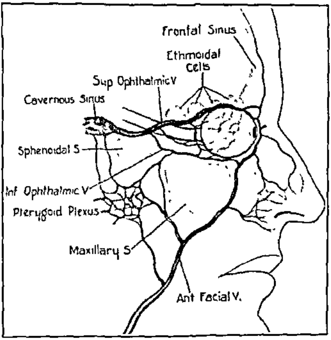


Fig 22 —The relationship of the contents of the orbit to the venous circulation of the orbit, and the surrounding structures (Cohen)

large quantities of blood from cerebral channels, could explain the cerebral complications which follow such ligations. (4) It creates increased pressure within the carotid sinus, where increased pressures have the effect of lowering the blood-pressures and of slowing the heart action. Such a sudden and severe fall in intra-vascular pressures could result in thrombosis of cerebral vessels with resultant hemiplegia or death Ligation of the common carotid, on the other hand (1) shows a minor incidence of complications in the form of hemiplegia as compared with ligation of the internal carotid. (2) It reduces the blood flow in the internal carotid by about one-half, so that in effect the internal becomes a branch of the external, and in certain cases may be an important channel of collateral circulation to the brain. (3) Because of the reflux from the external into the internal, it becomes

[1] Am. Jour. Ophth., Series 3, vol. 17, December, 1934.

possible to carry out a truly fractional ligation of the internal carotid, which may conceivably make it possible to reduce the *flow through* a fistula between the internal carotid and the cavernous sinus without stimulating a reversed flow from the distal segment. (4) It reduces pressure within the carotid sinus, creating thereby impulses which raise blood-pressure and increase the heart-rate; *in turn, tends to prevent or overcome* slowing of the circulation in cerebral areas.

Figure 22[1] illustrates the relationship of the venous circulation of the orbit to the surrounding structures, as the nasal accessory sinuses, the brain, and the cavernous sinus. Figure 23 illustrates the principal sympathetic pathway to the eye, for this has an importance only secondary to vascular conditions.

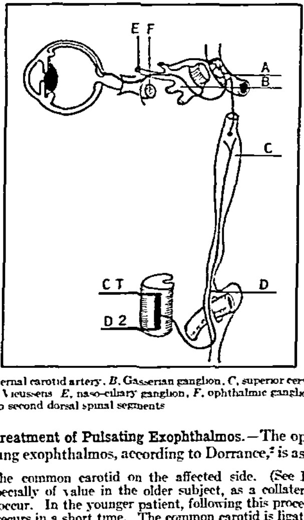


FIG 23 — *A*, internal carotid artery. *B*, Gasserian ganglion. *C*, superior cervical sympathetic ganglion *D* ansa Vieussens *E*, naso-ciliary ganglion, *F*, ophthalmic ganglion; *C-T* and *D-2*, seventh cervical to second dorsal spinal segments

Operative Treatment of Pulsating Exophthalmos.—The operative treatment of pulsating exophthalmos, according to Dorrance,[2] is as follows:

Ligation of the common carotid on the affected side. (See Fig. 24.) This operation is especially of value in the older subject, as a collateral anastomosis is less likely to occur. In the younger patient, following this procedure, the bruit disappears but recurs in a short time. The common carotid is ligated in the usual way, and within a week or two all the branches of the external carotid are ligated, except the internal maxillary and the superficial temporal. These branches of the external carotid may be ligated at one or more sittings, depending on the amount of *arteriosclerosis* present. Ligation of the internal carotid. This will practically always reduce the pressure, but as the only collateral circulation possible is through

[1] Cohen, Arch. Ophth., March, 1936.
[2] Am. Jour. Ophth., Series 3, vol. 13, August, 1930.

the circle of Willis, we not infrequently have such a reduced circulation to that portion of the brain supplied by the internal carotid that a hemiplegia occurs. When ligation of these vessels is undertaken, the operation must be done under local anesthesia. In the case of the common carotid the ligation should be a gradual cutting off of the blood stream rather than an immediate blocking. If ligation of the internal is done, the wound should be left open and the patient's condition constantly observed, so that if any untoward symptoms develop the clamp may be removed. Paralysis usually occurs in the first twelve hours after ligation, though it may not appear for twenty-four or thirty-six hours.

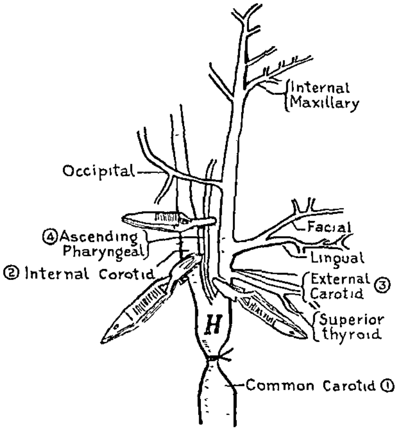


FIG 24 —The surgical approach for pulsating exophthalmos. (Dorrance)

Dorrance has never seen the rationale of ligating the veins of the orbit, though in the literature a few good results are reported following this procedure. In a number of the successful cases, however, a previous ligation of either the common or the internal carotid had been done. Ligation of the veins is not without danger, and he is opposed to this procedure. Terry and Mysel[1] exposed the internal carotid artery and injected 25 cc. of a thorium dioxide solution into it. A series of roentgen-ray films was taken at intervals during and after injections to prove that an abnormal arteriovenous fistula existed between the internal carotid artery and the internal jugular vein in the upper part of the neck. The jugular and lingual veins were tied between two ligatures, the common facial vein having been ligated at the time of injection of the thorium. The region of the bifurcation and the internal carotid artery for 1¼ inches above the bifurcation

[1] Jour Am Med Assn., 103, 1036, October 6, 1934.

were infiltrated and boggy, evidently because of the injection of the thorium. For this reason, and also to prevent the back "swish" from the external carotid, the common carotid is to be ligated first. The incision was then carried farther up the neck and the internal carotid artery was exposed well above the part infiltrated by the thorium and was ligated at this point.

Gazepis[1] reported a case of unilateral exophthalmos, with glaucoma, resulting from rupture of the carotid into the cavernous sinus. The patient first presented an abducens paralysis, then exophthalmos, without pulsation, but with a swishing sound over the temples, and later glaucoma appeared in the exophthalmic eye with tension up to 82 mm. of mercury. The fundus showed marked dilatation and tortuosity of the veins. Following ligation of the left internal and external carotids the eye became soft and the exophthalmos decreased. Hemiplegia, however, developed on the right side and several days later the patient died. The autopsy showed softening of one hemisphere of the cerebrum with an aneurysm of the left carotid into the cavernous sinus.

FIG. 25.—Anatomical relationship within the orbit, as viewed from above. (After Duke-Elder.)

Foreign bodies in the orbit are not uncommon. The history is clear-cut, usually, and the roentgen-ray picture will clear up any doubts which may exist. The history should also reveal the substance of the foreign body. Removal, if the foreign body is of steel or iron, is not essential in the absence of infection or other possible complications. Other materials, however, may cause late complications of a serious nature, and their removal may be quite necessary. Optic nerve pathology may develop, if it is not present from the start. Removal, in the usual case, should not be attempted without a biplane fluoroscope. The anatomy of the orbital contents, as illustrated in Figure 25, must be well known before surgery is attempted.

Inflammatory exophthalmos is a condition usually confined to one orbit. It may, however, become bilateral. This bilaterality may occur simultaneously, but usually there is quite an interval of time between an involvement of the two sides. In considering the routes through which the inflammation can enter the orbit, Eagleton[2] states:

> They are, (a) from in front, by way of the superior ophthalmic plexus, (b) from below, through the pterygoid plexus, or through the inferior ophthalmic plexus, or (c) medially from the nose. Endophlebitis of the vessels within the space, (a) may remain thrombophlebitis of one or the other of the ophthalmic veins, or it (b) may

[1] Arch. f. Ophth., Berlin, 110, 375, December 23, 1922.
[2] Arch. Ophth., 14, 1, July, 1935.

cavernous and lateral sinuses. There is no complete agreement regarding the mechanism producing these signs; and so often, the ophthalmologist is called upon for assistance in making the diagnosis of this condition.

The ocular changes of thrombosis of the superior longitudinal sinus are even less well understood than are the signs of cavernous and lateral sinus thrombosis. Some of the conditions hitherto diagnosed as serous meningitis, pseudo-tumor of the brain, or chronic arachnoiditis, etc., may be due to thrombosis of the venous sinuses in the presence of an abnormal venous sinus pattern. These possibilities must be considered with the anatomico-pathological findings in septic thrombophlebitis of the cavernous and lateral sinuses.

Aseptic thrombosis, (1) characteristically occurs in the non-paired sinuses; (2) is rarely associated with purulent infection; (3) shows a tendency to organization or resorption; (4) is rarely complicated by meningitis; and (5) in one-half the cases is followed by extravasation into the brain and a tendency to softening. Septic thrombosis is characterized by (1) occurrence in the paired sinuses; (2) frequency of purulent infection, meningitis and cerebral abscess; (3) a tendency to purulent degeneration of the thrombus; and (4) rare occurrence of extravasations into the cerebrum and cerebellum. (Walsh.)

The thrombi grow in the direction of the flow of the blood stream, but they may also develop in the opposite direction. Such retrograde development is frequent in the intra-cranial venous sinuses, where it may be accounted for by the absence of valves in many of the venous channels as well as by the plentiful collateral circulation. Septic thrombi result in bacteriemia and septicemia and through direct extension may give rise to abscess of the brain and meningitis.

In septic thrombophlebitis of the cavernous and lateral sinuses, the chemosis appears to parallel the amount of exophthalmos which may be unilateral or bilateral. The degree is variable, and it is much less marked when the cavernous sinus is involved through a retrograde extension from the lateral sinus than when it originated from an anterior infection. The edema of the lids is a striking feature in cases of fulminating thrombosis, especially when the thrombosis rises from an anterior infection. It appears that infection rather than vascular obstruction accounts for this swelling of the lids. Walsh agrees with Faulkner that swelling of the lower lid is not pathognomonic of thrombosis of the cavernous sinus, and that this may be due to an infection of the antrum or of the ethmoid sinus. Paralysis of the extra-ocular muscles is an early symptom. Ptosis develops later. As Behr believes, the external ophthalmoplegia may be purely mechanical, due to a lesion of the nerves in the cavernous sinus, caused by the pressure or by the inflammation. Internal ophthalmoplegia is rarely encountered at the first examination, and it is described as a late symptom. Parsons stated that paralysis of the external rectus muscle of the second eye is the first sign of involvement in the second eye. He thinks that such a paralysis is to be explained either by basilar meningitis or by increased intra-cranial pressure. Figure 26 is a case of orbital thrombophlebitis O.D. with secondary glaucoma, optic atrophy, and with the formation of a retrobulbar inflammatory mass demanding exenteration of the ethmoid sinus.

Walsh states that thrombosis of the longitudinal sinus as a primary form usually commences in the middle fifth of the superior longitudinal sinus. Anatomically, the high position of the sinus, low pressure, slow current,

and the presence of pacchionian bodies predispose to it. It occurs usually in debility of infants and as a result of changes in the blood itself, notably in chlorosis. Jacksonian convulsions occur frequently. Symptoms of involvement of the pyramidal tract confined to the lower limbs may be present. Conjugate deviation of the eyes occurs often. Exophthalmos has been reported, but rarely. *Papilledema and engorgement of vessels of the* scalp, retina and conjunctiva occur, but, on the other hand, there may be a complete absence of these signs. When the thrombotic process is septic and has extended to the longitudinal sinus from the lateral sinus, the prognosis for life is poor. Doyle (quoted by Walsh, which see) in describing this type, concluded that, in the absence of meningitis, early apathy or stupor in a patient with evidence of thrombosis of the transverse sinus secondary to otitis media indicates infectious *thrombosis of the superior longitudinal* sinus by retrograde extension, especially if associated with choked disks or *convulsions*. When tumor or inflammatory disease can be excluded, Jacksonian seizures showing progression from one foot to the other or

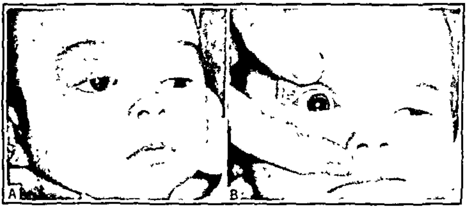


FIG. 26.—Orbital pseudotumor originating in a thrombophlebitis followed subsequently by secondary absolute glaucoma and optic nerve atrophy—the entire process from onset to the enucleation extended over a period of less than three months

beginning in the foot and gradually involving the homolateral upper extremity suggest impairment of the circulation of the cerebral veins and *probably thrombosis of the superior longitudinal sinus.* *Abrupt onset of* symptoms of increased intra-cranial pressure with fluctuations suggest thrombosis of the superior longitudinal sinus as well as ventricular tumor. The absence of the element of progression after a fair length of time or actual regression of symptoms is suggestive of thrombosis of the superior longitudinal sinus. If the syndrome is associated with edema of the lids and dilatation of the veins of the eyelids and forehead, and if fracture of the skull, orbital and periosteal infections and thrombosis of the cavernous sinus can be excluded, the diagnosis is established. Thrombosis of the *lateral sinus has as its outstanding symptom, papilledema.* *In most* instances, this is bilateral, though it has been reported as unilateral as well. Benedict feels that the edema simply signifies and does not *indicate* its cause. Abscesses of the brain and meningitis are frequent causes. In the original paper[1] Walsh's conclusions are as follows:

[1] Walsh, Arch. Ophth., 17, 46–65, January, 1937.

In the recent investigations which Woodhall carried out, he calls attention to the importance of variations in these cases as the result of variations in the anatomy of sinuses themselves. Among others, Linsor, Krummer, and Eagleton have reported cases in which at autopsy thrombosis was found to be associated with abnormalities of the unaffected sinuses. Bilateral sinus thrombosis or unilateral sinus thrombosis, when a great disparity in the size of the lateral sinuses exists, has been observed to result in increased intra-cranial pressure. Recently, abnormalities of the sinuses have been reported as responsible for negative or falsely positive readings in the Tobey-Ayer modification of the Queckenstedt test as employed in the diagnosis of thrombosis of the lateral sinuses. These clinical observations, verified by the occurrence of similar cases during the period of these investigations, have led to the conclusion that inadequate venous drainage results in increased pressure. Ordinarily the lateral sinus of the opposite side can take care of the extra volume of blood when one lateral sinus is thrombosed, but if there is not an adequate cross-circulation or if the unobstructed lateral sinus is small there is resultant back pressure and consequently an increased intra-cranial pressure. It is suggested by Woodhall that this is the anatomic basis for bilateral papilledema as observed in acute thrombosis of the lateral sinus and also in certain cases described as instances of serous meningitis when there is a history of an otitic infection and a sinus block can be demonstrated.

Tenonitis has been ascribed by Shoemaker[1] as a cause for unilateral exophthalmos. It may be a part of orbital cellulitis, or separate from this, prodromal to panophthalmitis, and has been seen in a suppurative form following muscle surgery. The symptoms of proptosis, of chemosis, of pain upon motion, and of restricted motion are significant. Syphilitic and tuberculous periostitis both cause moderate degrees of exophthalmos. The position of the diseased bone, the roentgen-ray examinations especially when augmented by the lipoidal injection of a sinus, the serology, and other allied signs will assist in the diagnosis. The chronicity of these two is their outstanding feature.

Engelking[2] has described exophthalmos from hyperplastic tuberculous lymph nodules, which he called tuberculoma and felt that it probably originated from the conjunctiva. They are, however, usually bilateral, though unequal, and the picture is similar to that seen in pseudo-tumor. Relative to the diagnosis of periostitis and tenonitis, Shoemaker[3] feels the differential diagnosis is generally not difficult as both have many common symptoms. The boring, deep-seated pain with nocturnal exacerbations together with external signs serve to implicate the periosteum in the inflammatory process. Tapping with the finger around the orbital margin, so as not to disturb the orbital contents, will serve often to locate the affection in the bones. If this can be done without pain, the bone or the periosteum is not involved. *Vice versa*, if gently pushing back the eyeball, with just sufficient force to reach the soft parts only, causes marked pain, the condition is tenonitis or cellulitis. Tenonitis, of the two, seems to cause the greater pain. Syphilitic periostitis is generally a tertiary manifestation. Third nerve paralysis with the levator functioning is rather likely periosteal in origin. Luetic periostitis is more common in the roof and rim of the orbit (excluding suppurative forms from the frontal sinus), while the tuberculous form in the greater number of cases selects other positions, and in general is more uncommon. Pseudo-tumor is a term used for a slowly

[1] Modern Ophth., 3d ed., F. A. Davis Company, Philadelphia, 1933.
[2] Klin. Monatsbl f. Augenhlk., Stuttgart, 70, 100, March 10, 1923
[3] Disease of the Orbit; Section, Modern Ophthalmology, J M Ball, 3d ed, F. A. Davis Company, Philadelphia, 1933.

developing exophthalmos from a low grade non-mycotic infection. Fry[1] described such a case with extensive microscopic studies. Figure 27*A* is a microphotograph of the retrobulbar tissue removed surgically.

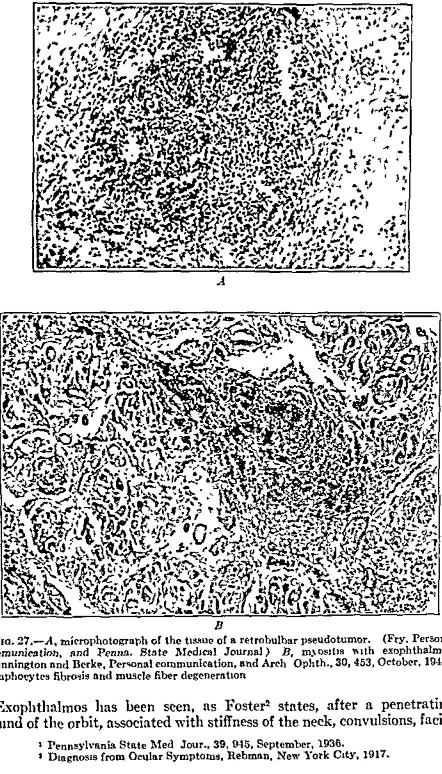


Fig. 27.—*A*, microphotograph of the tissue of a retrobulbar pseudotumor. (Fry, Personal communication, and *Penna. State Medical Journal*.) *B*, myositis with exophthalmos (Dunnington and Berke, Personal communication, and Arch. Ophth., 30, 453, October, 1943.) Lymphocytes fibrosis and muscle fiber degeneration

Exophthalmos has been seen, as Foster[2] states, after a penetrating wound of the orbit, associated with stiffness of the neck, convulsions, facial

[1] Pennsylvania State Med. Jour., 39, 945, September, 1936.
[2] Diagnosis from Ocular Symptoms, Rebman, New York City, 1917.

palsy, and spasms of the throat—due, as one would surmise, to tetanus. An acute exophthalmos may be symptomatic of an abscess in or about the lacrimal gland, or be due to an acute dacryoadenitis from invasion by pyogenic organisms.

Exophthalmos from chronic sinus pathology is common. Dowman's[1] case and Sir St. Clair Thompson's[2] case of mucocele of the frontal sinus, Ferreri's[3] pulsating mucopneumatocele of the frontal sinus, Reverschon's and Worms',[4] and Bower's[5] cases of mucocele of the ethmoid, Hajek's[6] case of mucocele of both of these sinuses, and Peter's[7] case of exostosis or chronic periostitis of the ethmoid are all inclusive and classical examples of these somewhat rare complications. Figure 28 is a roentgen-ray photograph of a mucocele of the ethmoid of the author's and illustrates well that roentgen-ray diagnosis plus careful clinical investigation by a competent *rhinologist are necessary but adequate.*

Fig. 28.—Roentgen-ray of an orbital-ethmoidal mucocele.

Cholesteatomas have been reported of such an extensive size, as to break through the roof of the orbit and cause proptosis. Wolff[8] reported a study of the 18 cases which up to that time had appeared in the literature. Their origin is from the diploë of the frontal bone as a result of chronic inflammation in the sinus. Their earliest symptom is pressure pain, later to be followed by exophthalmos, swelling of the lids, and choked disk. Wolff states that roentgen diagnosis is difficult, except that there may be bone destruction, and the formation of fistulæ. The description of these cases, as cholesteatoma, is often incorrect, as Knapp states, and pathologists seem to be abandoning the belief that they are a form of tumor, *i. e.*, neoplastic in origin.

Actinomycosis, anthrax, trichinosis, hydatid cyst, and mycotic pseudotumor have been repeatedly reported, though not uncommonly, as the

[1] Jour Am Med. Assn., 81, 1014, September 22, 1923.
[2] Jour. Laryngol. and Otol., Edinburgh, 38, 365, July, 1923.
[3] Arch Internat. de Laryngol., etc., Paris, 1, 973, September-October, 1922.
[4] Arch. Internat. de Laryngol., etc., Paris, 1, 682, June, 1922.
[5] Am. Jour. Ophth., 7, 218, March, 1924.
[6] Monatschr. f. Ohren u. Laryngol., Rhinol., Vienna, 58, 359, May, 1924.
[7] Presentation to Staff, Graduate Hospital, University of Pennsylvania, October, 1932.
[8] Beitr. z klin. Chir., 130, 215, 1923.

cause of unilateral exophthalmos. The diagnosis in the first of the cases mentioned should be simplest, because of the general symptoms as well as the local symptoms of abscess formation, the history of the case, and the laboratory studies. Blood cytology studies and the orbital pains will assist in the case of the third, plus a history of the characteristic muscle pains. The last two, however, depend largely upon an orbital wall resection for diagnosis, plus, perhaps, the elimination of every other possibility in any case under investigation. With infections by the streptothrix the symptoms are those of a subacute to acute infection, suppuration, the occupation of the patient, and the microscopic and macroscopic findings. The findings upon which a diagnosis of anthrax is based depend wholly upon the acute suppurative process, the occupation of the patient being especially important, and here also, the gross and microscopic laboratory findings. Pascheff[1] discussed actinomycotic tumor of the orbit with the characteristic unilateral exophthalmos, with ptosis, with a history of orbital injury (frequently years before) and the abscesses with the fistulæ years later. The cultures show the streptothrix. These fistulæ may heal after several months of potassium iodide medication, but surgical removal is usually necessary for a complete cure. Mycotic pseudo-tumors of the orbit may continue, without fistulæ. for several years and in this form they are not extremely rare. Gonzales'[2] case presented paralysis of the third nerve, exophthalmos, mydriasis and a paralysis of accommodation, cutaneous and corneal anesthesia, and corneal ulceration with hypopyon. If the correct diagnosis is not made, these cases will continue on to complete immobility of the eyeball, to blindness from optic nerve atrophy, to emaciation of the patient, and at last to the development of the characteristic multiple fistulæ. O'Brien[3] presented a case wherein surgical exploration was without success, and death occurred from a cavernous sinus thrombosis. In this case positive streptothrix cultures were obtained from the brain at the necropsy. Matthias Foster[4] discusses the symptomatology of a trichinosis infection of the ocular muscles, largely upon the basis of an oculomotor paralysis of recent duration which cannot be ascribed to any lesion of the nerve supply, the presence of a doughy edema of the lower lid, and with other general symptoms of this infection. Hydatid cysts are due to the echinococcus, and cystic degeneration due to the cysticercus cellulosæ. Both conditions are rare, especially the second of the two. Berlin, Parsons, Aniceto-Solare,[5] Lagrange, L'Heureux and Wood[6] have written about these unusual cases. The diagnosis, apart from aspiration, depends upon the negative Wassermann, the absence of inflammation, the frequent attacks of blindness without the presence of fundus pathology, and a palpable tumor mass, especially if the patient lives or has lived in a land where hydatid disease occurs. These cysts may lie either free in the orbit, or within the muscle cone.

Xanthomatosis is essentially a bilateral condition. According to Benedict[7] it is a disease related to the metabolism of lipoids, and should include

[1] Ztschr f Augenh , 47, 109, Beilage No 6, Berlin, 1922
[2] Mycotic Tumor of the Orbit, Riv Cubana de Oftal , Havana, 4, 76, January-June, 1922
[3] Am Jour. Ophth , 18, 123, February, 1935.
[4] Diagnosis from Ocular Symptoms, Rebman, New York City, 1917.
[5] Arch. d'ophth , 39, 406, 491, 1921
[6] Brit Jour. Ophth., 9, 4, January, 1925
[7] Berens, The Eye and its Diseases, Philadelphia, W. B Saunders Company, p. 332, 1936.

Gaucher's disease, Niemann-Pick's disease, and the Schüller-Christian's disease; it also occurs in icterus, in diabetes, and in pregnancy, as well as in the form of a so-called essential xanthomatosis. The disease of children, due to disturbance of lipoid metabolism, is characterized by deposits of lipoids, chiefly cholesterol and its esters, in various organs and tissues of the body. Among the chief symptoms are defects in the bones, exophthalmos, diabetes insipidus, gingivitis, cessation of growth, and occasional adiposogenital dystrophy. Exophthalmos is often an early sign. Roentgenograms reveal the defects in the bones of the skull caused by the deposits of lipoid substance, and formation of thick fluids which give a characteristic cystic sensation on palpation. The lesions of the skull are similar to those of osteomyelitis as seen in the roentgenograms, and there may be some confusion in the diagnosis. Surgical intervention has been of little benefit. Mild cases have been cured by application of radium and roentgen-rays over the affected areas. The defects in the cured cases are filled with new bone, thicker and more dense than the surrounding bone. Wheeler,[1] Knapp,[2] Heath[3] have all published their experiences. Knapp speaks of it as a condition of the reticulo-endothelial cell and hyperplastic in character. Evisceration of the orbit alone is confirmatory of the diagnosis though, as Wheeler did, biopsies are equally efficient.

The diseases of the blood, of the lymph, and of the hæmatopoietic system are responsible for many cases of unilateral and bilateral exophthalmos. Rickets, scurvy, and hæmophilia are the first to be mentioned. These cases result in subperiosteal hæmorrhages, deep in the orbit, which occur rather abruptly and are accompanied by hæmorrhagic extravasations into the skin of the upper and lower lids, especially the lower. The general symptoms which identify these conditions, otherwise, should be sufficient for making a correct diagnosis. Lymphosarcoma (lymphoblastic), lymphoendotheliomata, acute and chronic leukemia, and possibly Mikulicz's disease are all allied conditions. With the exception of the leukemias, the blood picture is not especially characteristic. As O'Brien and Leinfelder[4] state, all types of lymphoma show progressive, painless enlargement of the cervical and lymph nodes, increase in the size of the spleen and liver, and in the later stages, secondary anemia and cachexia. With this exception, the diagnosis must be made, usually, at postoperative or postmortem microscopic examination. In lymphosarcoma, the lids are usually involved by nodules, the exophthalmos is apparently of moderate degree, and age seems to have no relationship to the condition. The condition is rare, and similar in general symptomatology to Hodgkin's disease. The cases may develop cranial extensions. The diagnosis depended wholly upon the microscopic picture of the tumor masses. Figure 29 is one of their (O'Brien and Leinfelder) cases of this malignant lymphoma of endothelial nature. Acute and chronic leukemia are not commonly accompanied by exophthalmos. In 96 cases of lymphatic leukemia reviewed by Reese and Guy,[5] 2 per cent showed exophthalmos. The blood picture is quite characteristic. Retinal hæmorrhages are most common, the retinal vessels have a pale, even milky

[1] Schüller-Christian Disease, Arch. Ophthal., vol. 11, January, 1934.
[2] Xanthomatosis of the Orbit, Arch. Ophthal., vol. 11, January, 1934.
[3] Ocular Lipoid Histocytosis, Arch. Ophthal., 10, 342, September, 1933.
[4] Am. Jour. Ophth., 18, 123, February, 1935.
[5] Am. Jour. Ophth., 16, 718, August, 1933.

appearance, and there is rather often a soft edematous swelling of the lids. Figure 30 is one of O'Brien's cases of this condition.

Mikulicz's disease, which is similar to these cases of leukemia, consists of a chronic bilateral enlargement of the lacrimal and the salivary glands in

FIG. 29.—Malignant lymphoma (O'Brien and Leinfelder, personal communication.)

FIG 30 —Acute lymphatic leukemia (O'Brien and Leinfelder, personal communication)

which the characteristic microscopic finding is a marked infiltration with lymphocytes and with endothelioid and giant cells also occasionally present. Wolff[1] states that the etiology is much disputed and probably varies in different cases. Exophthalmos has been seen in Hodgkin's disease, though considering the relative frequency of this condition proptosis is rare. The author saw it in a case—after cachexia had advanced rather far, unilateral exophthalmos developed. The eye in which it occurred was on the opposite side of the body to that in which there was the greatest amount of enlargement of the cervical lymph nodes. A palpable mass was found on the external rectus in the outer superficial angle of the orbit. Myeloblastoma and myelogenous leukemia are conditions which are rather similar to the leukemic conditions except for the presence of premyelocytes and myelocytes in the blood stream. The white cells are usually over 100,000 in number, progress is rapid, and massive hæmorrhages occur into the tissues of the orbit. The blood picture cannot be mistaken: the differential count showing myeloid series over 90 per cent and, morphologically, of an extremely

FIG 31 —Myeloblastoma (O'Brien and Leinfelder, personal communication)

[1] Pathology of the Eye, Philadelphia, P. Blakiston's Sons & Co , 1935.

embryonal type of cell. Figure 31 illustrates one of their cases. The massive late hæmorrhages are rather well seen. These tumor masses, when of a green color and when infiltrating are spoken of as chloroma. Barnert's[1] case was most characteristic. In his case the disease advanced into the bones of the skull and proved fatal in one month. In these, Piney[2] states that the mode of infiltration of the tissue is similar to that characteristic of malignant tumors in general. The blood picture of his case consisted of 85 per cent of myeloblasts and 15 per cent of premyelocytes and myelocytes.

SPACE TAKING ORBITAL LESIONS

Relative to the space taking lesions which appear in the orbit, there are five general classes to be considered. The first is that of true cysts, the second of gummata, the third of benign neoplasms—the fourth of malignant neoplasms which are primary in the orbit, or primary in the eyeball and by extension through the globe invade the orbit; and the last, orbital metastatic neoplasms from the nasal accessory sinuses, the liver, the kidney, the adrenals, etc. All of these have as common symptoms, a slowly developing exophthalmos, usually with but few inflammatory changes; fundus changes are rare save in those cases with primary retinal, choroidal, or papillary involvement, and age limits are roughly individual and peculiar to certain types of cases. Less common signs and symptoms would be duration of the exophthalmos, roentgen-ray changes in the bones of the orbit, and changes in the normal density of the orbital contents, various oculo-motor disturbances, the direction of the proptosis, inflammatory signs, and the presence of primary neoplasms in some extra-orbital portions of the body.

The first class will include dermoid cysts and sebaceous (retention) cysts. One of the classical examples of this was the case of a girl, aged eighteen years, with exophthalmos which started at the age of seven years. A mass could be palpated in the orbit in the past two years of the patient's life. There were no oculo-motor or visual disturbances, but diplopia had developed recently. A Krönlein (Kroenlein) resection of the orbital wall showed an orbital cyst containing rolls of hair, and much sebaceous material, the internal wall of the cyst being adherent to the optic nerve sheath. Complete removal was accomplished save for that portion attached to the neural sheath. This was allowed to remain. The length of time the exophthalmos was present, its onset at an early age, its slow development, and the absence of any other pathological signs was sufficient for the diagnosis The roentgenogram showed a mass in the orbit, retrobulbar, but not of a density sufficient to make one consider a fibroma or an osteoma. Lipoma might have been considered from the standpoint of age, development, and length of duration, but the non-compressibility of the palpable tumor mass, the direction of the proptosis, down and in, and the density of the roentgen-ray shadow made cyst the more probable diagnosis.

An interesting oil cyst, retrobular and subperiosteal, was reported in 1923 by Knapp[3] with a complete pathological report, the contents being of such a material that it would make one believe they belong to the group of dermoid tumors. According to Knapp and even earlier to Lagrange

[1] Arch. Ophth., 53, 454, September, 1924
[2] Diseases of the Blood, Philadelphia, P. Blakiston's Sons & Co., 1928.
[3] Arch. Ophth., 52, 163, March, 1923.

(quoted by Knapp) these cysts are most common in the prelacrimal region within the orbit.

Fig 32 —Progress in the advancing exophthalmos of a bone cyst of the right orbit extending over a period of three months A, original, B, three months later

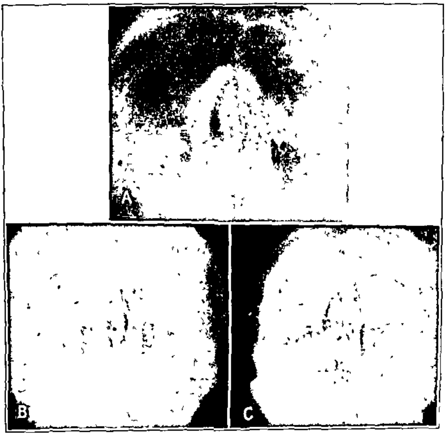


Fig. 33 —The progressive changes in the roentgen-rays, case of Figure 32, extending over a period of nine months, at three months intervals A, original (see B of Fig. 32). B, three months later; C, three months later.

Bone cysts of the orbit are quite rare, usually occurring at the inferior outer angle of the orbit. Etiologically, the cause for them is unknown. It

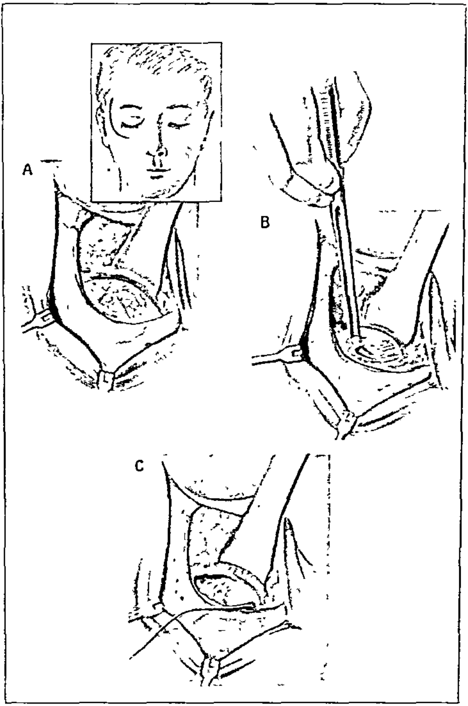


FIG 34 —Operation for bone cyst at outer inferior orbital angle. In *C* the probe lies in the maxillary antrum.

may be that a few are connected with upper retained root fragments, or may be the result of chronic maxillary sinus pathology. Their progress is very slow.

The roentgen-ray picture is not at all conclusive. It is difficult to differentiate these from an osteogenic sarcoma. The history of the case, that is, the long-standing exophthalmos, and its very slow progress, are the two outstanding characteristics. Figure 32 is such an instance, and Figure 33, the roentgen-ray pictures of the case. In this instance, the diagnosis was confirmed at operation. Figure 34 illustrates the technique for use in the operation of this case.

FIG 35 Roentgen-ray of an osteoma of the orbit

Gummata of the orbit are apparently becoming much more rare than formerly. The patients usually have acquired syphilis some years previously, all have unilateral pain in the affected eye, worse at night; unilateral exophthalmos with paralysis of some of the extra-ocular muscles, even to complete ophthalmoplegia externa, and most of them show abnormal pupillary reactions upon the affected side. They may show fundus pathology in the nerve head. Kemp[1] states that the pain is the most characteristic symptom of these cases. In addition to those cases which show or present a true gumma, lues may also be the cause of exophthalmos with many of the other symptoms described above, due to periostitis and or with osteitis. One case, seen on Peter's service, at the Graduate Hospital, Philadelphia, was quite characteristic. The patient was a colored girl, aged twenty-two years, with a positive Wassermann, with the characteristic pains described by Kemp and with 1 cm. of exophthalmos on the right, accompanied by a complete third nerve paralysis. The fundi showed bilaterally vascular pathology, most unusual for a patient of her age. Recovery was uneventful under antiluetic treatment, continued for three months.

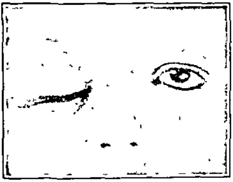


FIG 36 —Neurofibroma of the orbit

Of the benign tumors, fibroma, lipoma, osteoma and osteofibroma, and

[1] Arch Dermat. and Syph., 8, 165, August, 1923.

neurofibroma will first be discussed. The fibromata seem to be made up of white connective tissue, showing some hyaline degenerations, and mitotic figures are extremely rare. They may recur, however, if not completely removed. Relative to the osteomata, it is at times difficult to decide whether they are due to a bone hyperplasia or heteroplasia. Certainly, the exostosis one sees in chronic ethmoidal disease are the latter and due to chronic inflammation or to chronic traumatic insult. On the other hand, true hyperplasia osteomata appear in the orbit in situations where it is quite certain that the tumor cannot be due to preëxisting inflammation. Figure 35 is quite typical of the roentgen-ray picture of an early but definite osteoma.

Neurofibroma, or fibroma molluscum, of the plexiform variety, appears rather commonly on the face and in the orbit. The tumor is derived from the connective tissue of the sheath of Schwann. Figure 36 illustrates a typical case of neurofibroma. These cases have not only a unilateral exophthalmos from the retrobulbar growth of the new tissue, but also the *tumor in many instances causes deformity of the floor and roof of the orbit.*

Much has been written recently about neurofibromatosis from a pathological and histological standpoint. This has included not only the microscopic pathology, but also the many various allied accompanying defects and findings. The clinical correction of these cases, however, has been neglected in the literature to an astonishing degree. It is rather likely that one reason for this is because the various anatomical defects which appear are so numerous, so varied, and so individual to each case that it would demand quite a series of cases before any surgical procedures could be outlined, sufficiently embracing to be worth considering.

These peripheral nerve tumors grouped together with glial neuromata (the ectoderm tumors of Schwann's sheath), von Recklinghausen's disease, the neurofibromata of the cranial nerves, and neuronomata are more commonly spoken of as plexiform neuromata. They have many characteristics which are common to the group, but of themselves are definitely individual. Their surgical dissection demonstrates without any doubt Wilson's statement that they result from neurofibromatous proliferation of the terminals of the entire distal fan of a nerve. Penfield feels that many of these conditions have, etiologically, a double aspect; one, a background of congenital anomalies, (neurofibrosis tissue) and on this is superimposed, two, neoplastic areas not to be distinguished from peri-neural fibroblastomata (of mesodermal origin). The statement emphasizes the necessity for very thorough removal when operating. Even though these masses of themselves are not essentially neoplastic, in terms of malignancy, still following incomplete removal, and perhaps as a result of surgical trauma, sarcomatous transformation has occurred. Properly regarded as benign (Wilson) in the sense of pursuing leisurely development, still many men, as Thompson, Cestan, Burger, Gray, and others, have seen this sarcomatous change occur. The sarcomatous areas may appear in patches, or the growth becomes uniformly altered to this type of malignancy. In addition, as seen by Franchet and Labbé, a general state of sarcomatosis may develop, as though some congenital predisposition to tumor growth of different sorts and of different tissues lies behind the neurofibromatous disease.

The tumor tissue grows very slowly, but steadily. Inadequate and incomplete removal demonstrates this in a rather distressing manner. The

anatomical defects which appear and which need correction are as follows: (1) *the tumor tissue itself;* and (2) a brawny pigmentation of the skin, doughy in consistency, inelastic, infiltrated, with redundant skin about the tumor tissue, *even to the formation of hanging flaps, these frequently* covered with long, dark, curly, hairs. The skin in this condition will stand no tension whatsoever, bleeds copiously; and sutures, when placed with the least bit of tension, tear out very readily. It is almost as if one were suturing liver tissue. The distant café-au-lait spots so characteristic of this condition, showing themselves on the back, on the chest, and on the lower extremities, usually need no surgical removal. (3) Bone defects are seen as atrophy of the upper outer angle of the orbit, the lower outer angle of the orbit, and the floor of the orbit. One case was found with an encapsulated sequestrum of the outer wall of the orbit. Loss of, or defects of the zygomatic arch are quite common; spreading of the orbital suture lines is not at all uncommon, and one case was seen with a defect in the frontal bone. (4) Invasion of the orbit itself by tumor tissue is frequent. (5) Ptosis is *the most common finding, due not only to the weight of the upper lid,* but also to a rather interesting destruction of the levator palpebræ superioris or even with a posterior displacement of the levator. This is quite unusual. for in two instances, the levator was found and reattached. The orbicularis

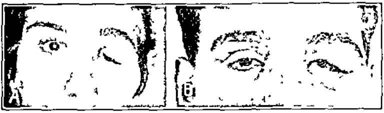


FIG 37 —Plexiform neurofibromata prior to any surgery

palpebrum oculi is affected similarly, that is, by deformation and by atrophy. These conditions of the upper and the lower lid also have minimal degrees of entropion, and of conjunctival deficiency. (6) Accompanying defects of the globe itself, as microöphthalmia, and (7) ocular motor disturbances, especially of the external rectus are found (8) One case of retrobulbar aneurysm was seen.

In the treatment of these cases, there is one thing which is certain, that is, *roentgen-ray therapy is of no value whatsoever in the treatment of the* condition. In one instance, however, it was of great benefit in cleaning up a chronic, long-standing dermatitis with marginal blepharitis residual after the major plastic correction had been completed, and it is valuable for depilation. The surgery usually must be done under general anesthesia, because in most instances, the soft tissue defects are so marked that infiltration anesthesia would be inadequate. The actual dissection of the tumor tissue, (which is easily recognized, as white, worm-like masses), must be very carefully done—to save tissues not involved, to prevent unnecessary scarring, and at the same time, to conserve *as much as is possible of skin,* muscle tissue, tarsal plates (if still present) and hair lines. Tumor tissue which extends into the orbit should be removed as meticulously as that lying in the lids. It will be of great assistance in these cases if careful

itself was wholly absent. The extent of brawny infiltration of the skin was very marked. He had many café-au-lait spots through his skin surface. Two of these are illustrated, Figure 40. The surgical removal of the neurofibroma was followed by such a large operative defect that it was necessary

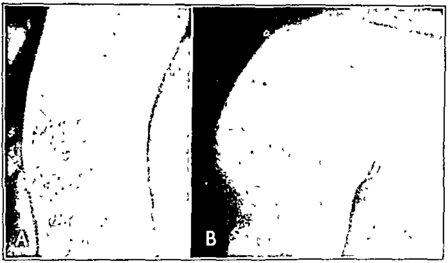


FIG. 40.—Case of Figure 37 *B*, showing café-au-lait spots on knee and on shoulder in plexiform neurofibromata.

to swing skin up over the angle of jaw and then to cover that secondary defect by a sliding flap from the neck. Figure 41, *A* is the front view of this case after this operation and *B* of Figure 41 is the side view. *A* and *B* of Figure 42 illustrate this flap schematically, and show the flap in place with the suture line accentuated. This case, following his surgery, had a

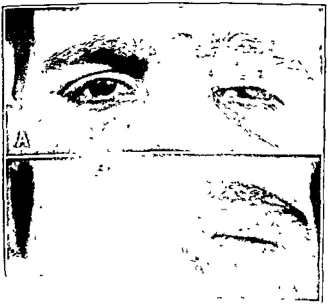
FIG. 41.—Case of Figure 37 *B*; *A*, front view of the case after operation; *B*, side view.

persistent recurrent folliculosis along the incision lines with a marginal blepharitis which remained resistant to treatment until roentgen-ray therapy was used. Figure 43, *A* and *B*, shows the case at the time of discharge.

5

Neglected neurofibromatosis can be a truly tragic situation. Figure 44 illustrates such a case. The condition existed since early life, and surgical correction was not sought until early adult life. A simple enucleation which was the first surgical procedure disclosed a tremendous neurofibromatous mass in the orbit with complete destruction of the floor of the orbit,

FIG. 42.—Case of Figure 37 *B*, schematic repair and position of suture line, accentuated following flap



the lids open; *B*, with the lids closed.

the lateral wall, into the temporal fossa, and gross defects in the roof of the orbit. The roentgen-ray pictures seem to confirm this, but demineralization of the bone had advanced to such a degree that preoperatively one could not be certain of the bone defects.

The second operation was the radical removal of the tumor mass. At that time a complete destruction of the superior and posterior, and lateral walls of the orbit was discovered. The neoplasm was extradural and in contact with the dura. The dura was torn twice while removing the tumor. There was, however, sufficient conjunctiva remaining on the redundant upper and lower lids that the dura, when closed surgically was covered by

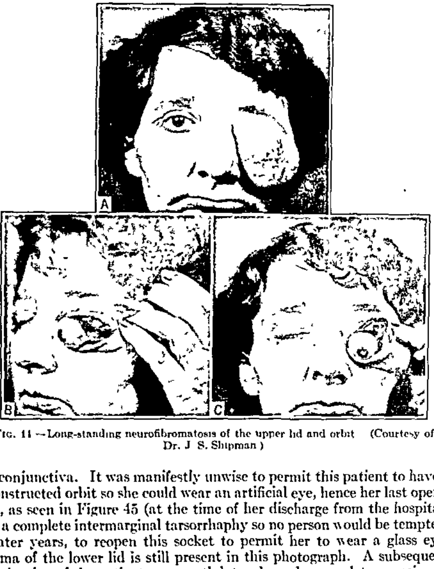


FIG. 44.—Long-standing neurofibromatosis of the upper lid and orbit (Courtesy of Dr. J. S. Shipman.)

the conjunctiva. It was manifestly unwise to permit this patient to have a reconstructed orbit so she could wear an artificial eye, hence her last operation, as seen in Figure 45 (at the time of her discharge from the hospital) was a complete intermarginal tarsorrhaphy so no person would be tempted, in later years, to reopen this socket to permit her to wear a glass eye. Edema of the lower lid is still present in this photograph. A subsequent examination of the patient one month later showed a complete recession of this. Figure 46 shows some of the various café-au-lait spots on the patient.

Myxoma and chondromyxoma have both been reported as the cause of unilateral exophthalmos. The first of these consists of cells of an embryonal type which grow very slowly, occasionally becoming sarcomatous. The

chondromata have typical fetal cartilage cells and occasionally, cartilage with stellate cells. They are at times myxomatous in character as well.

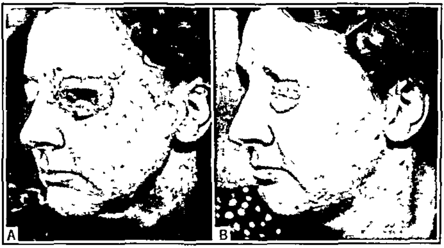


Fig. 45.—Same case as Figure 44 preceding. *A*, the enucleation and plastic correction; *B*, following the median tarsorrhaphy. (There is some edema still present in the lower lid. Many small nodules of neurofibromatosis can be seen on the neck.)

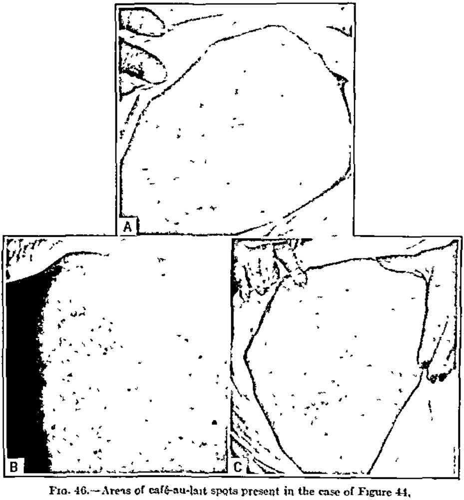


Fig. 46.—Areas of café-au-lait spots present in the case of Figure 44.

These tumors are encapsulated, hard and nodular. It seems when this encapsulation becomes imperfect they spread quite rapidly, though they do not metastasize. Ewing[1] reported such a case in detail.

Cylindromata were, at one time, thought to be endothelial in nature. Now they are more commonly considered as epithelial in type. The cells are arranged in cylindrical spaces which are filled with hyaline. This type of tumor most commonly occurs as part of the ordinary mixed tumor of the parotid gland. Zentmayer[2] quoted a case of this variety as connected with the lacrimal gland, and Agnes Baron[3] reported one such case in great clinical and microscopic detail. Her findings permit one to consider the lacrimal gland as an altered salivary gland, and to designate these tumor masses as progonoblastomas.

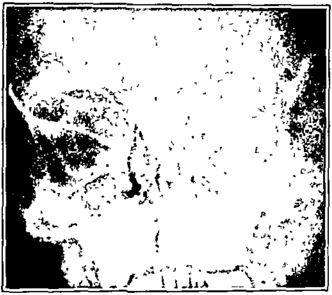


FIG. 47.—Roentgen-ray of adamantinoma of the orbit (O'Brien, personal communication.)

Psammomata are truly endothelial, consisting of whorls of endothelial cells with areas of centrally disposed laminated calcification Mitotic figures are not uncommon. These cases are rare, and seem to be connected with chronic nasal diseases. The case described by von Eicken[4] showed roentgenographic signs of ethmoidal disease with marked shading of the ethmoidal and frontal sinuses. The exophthalmos had been developing over a period of six years. At operation, von Eicken said, large masses of the tumor tissue were removed, and it was discovered that all of the dividing walls of the ethmoid bone and the anterior wall of the sphenoid sinus were lacking. The tumor mass crunched under the spoon like sand. Extensive hæmorrhage prevented a reliable radical extirpation. Sixteen days later, reoperation revealed a firm club-like tumor in the depths of the inferior nasal passage which nearly filled the cavity.

Adamantinomata are cystic tumors which arise from the paradental

[1] Neoplastic Diseases, 3d ed, Philadelphia, W. B Saunders Company, 1928.
[2] Am. Jour. Ophth, 9, 736, October, 1926
[3] Arch. f. Ophthal., 113, 31, 1924.
[4] Schweiz. med. Wchnschr., 52, 495, May 25, 1922.

epithelial débris. Sooner or later the capsule of these tumor masses ruptures and the disease extends rapidly into the antrum, the orbit, and into the cranial cavity. Figure 47 is the roentgen-ray of O'Brien's case of adamantinoma.

Hemangioma and lymphangioma are rather uncommon conditions. They consist of a tangled network of dilated blood- or lymph-vessels, usually congenital, tend to increase, and may become malignant by sarcomatous changes. The hemangiomata are usually bluish in color, and are, perhaps, the more common of the two. With the lymphangiomata, a marked proptosis is present, and exploratory operation through the conjunctival cul-de-sac shows a cyst with clear watery contents. The mass can be palpated in the orbit, is not tender, is freely movable and may fluctuate somewhat. Ring and Jones each presented interesting cases of orbital hemangiomata. Ring's case[1] accompanied by pulsating exophthalmos was the result of extension of a vascular growth into the orbit from the face, first noticed there at the age of two years. The patient had had a common carotid ligation six years before. This failed to stop the progress of the intra-orbital extension. Jones's case[2] had a blue prominence which first appeared in the left upper lid at the age of two weeks. Within six years it had progressed appreciably with moderate exophthalmos, with vertical displacement of the eyeball, with diplopia, and without bruit, nor did it change in size with any change in the position of the patient's head. (See Fig. 57.)

Plasmomata, or tumors of extra-medullary plasma cells, have been reported. Ewing states that they are commonly classed as lymphosarcomata but, being as a rule, benign processes with very indistinct neoplastic properties, it is most necessary that they should be differentiated from malignant lymphosarcomata. They may recur after extirpation and become associated with a chronic cachexia.

Endotheliomata are more commonly known by Cushing's preferred term, as meningiomata. These tumors, while not encapsulated, show no great invasive capacity, and they do not metastasize. On the other hand, certain cases have been reported wherein extensions appeared in the neighborhood of the original tumor. The roentgen-ray of a case of the author's is shown in Figure 48. Such a case is not definitely certain, as to diagnosis, until after operation. The adult age of the patient, the slowly developing exophthalmos, the absence of pain and of tenderness, the negative fundus findings, the absence of any history of trauma, and the extensive roentgenologic findings are necessary factors in making a preoperative diagnosis in any case. These cases, due to the orbital invasion, are not satisfactory cases for any surgery except that which would be most extensive and quite disfiguring.

Other endotheliomata have been reported as retrobulbar tumors but they are not of this type of tissue growth. The 2 cases reported by Williamson-Noble[3] demonstrates this. His cases were both in children, the first seemed to appear as the result of postoperative trauma in a squint case, and microscopically seemed (to the author) more like a plasmoma than a meningioma. The growth invested the optic nerve very closely,

[1] Am. Jour. Ophth., 7, 946, December, 1924.
[2] Northwest Med. Jour., 24, 11, January, 1925.
[3] Brit. Jour. Ophth., 7, 222, May, 1923.

and seemed to arise from the arachnoid about the optic nerve. The second of the two contained not only endothelial cells but also, blood spaces, fibrous tissue, cartilage and bone. He stated that the tumor was not a typical endothelioma, assuming that some pluropotential cells were cut off during embryonal life, later to resume activity; a teratoma of the orbit might be the correct diagnosis.

Rhabdomyoma has been reported as the cause of unilateral proptosis. This tumor originates in preëxisting striated muscle though it may occur in other heterologous regions. The tumor is rare, and occurs usually in the tongue and heart muscle, as the result, (Ewing), "of congenitally misplaced embryonic striated muscle." It metastasizes very rarely. Redslob[1] reported on the 3 cases seen in the literature and included a fourth. All of them occurred in children between two and five years of age, and caused an irreducible exophthalmos. In his case, the tumor mass upon the external rectus muscle had a subsequent recurrence, and when removed it showed

FIG 48.—Roentgen-ray of a meningioma of the orbit

the tissue of a typical round-cell sarcoma, quite unlike that seen in the first mass removed. Since the primary tumor showed zones of transition in which the morphological degeneration of the tumoral rhabdocytes could already be plainly traced there can be no doubt that this second tumor was a recurrence.

Neural or glial tissue tumors, both extra- as well as intra-neural, extra- as well as intra-ocular, are diagnosed according to the type of the predominate cell present. The work of Bailey, of Cushing, of Penfield, and of others has resulted in a differentiation of thirteen different types of glioma, depending upon their resemblance to the embryonal cell age; thus medulloblasts, *spongioblasts, and neuroblasts are found.* Through states of further differentiation, the medulloblasts would produce oligodendrogliomata; the spongioblasts, the astrocytomata; and the neuroblasts, the neuroma. *Neuroblastomata show histologically few if any glial fibers and are*

[1] Ann. d'ocul., 161, 721, 1924.

made up of cells resembling the primary neuroectoderm. They usually affect the adrenals in children, and metastasize frequently. Figure 49 *A* and *B* from Lowenberg's pediatric service at Philadelphia's Mt. Sinai


A *B*

Fig. 49 —Neuroblastoma *A*, taken three months before *B*. The child died shortly after *B* was taken. (Lowenberg, personal communication)

Hospital[1] is typical of such a case. The first picture was taken three months before the second, this last being taken a very few days before the death of the child. It shows the huge mid-line frontal bone extension which grew much more rapidly than did the retrobulbar metastasis. Figure 50 is a neuroblastoma reported by O'Brien which was primary within the orbit.


Fig. 50 —Neuroblastoma. (O'Brien, personal communication.)

Neuromata are essentially benign gliomata and are composed principally of both medullated as well as non-medullated fibers, though a careful search may show some cells. These have been reported frequently as adherent to the optic nerve, and can be diagnosed only at operation. Their growth is very slow, and not accompanied by any characteristic symptoms, little if any fundus pathology appears, and the roentgenogram shows a faint retrobulbar shadow.[2] The removal should be uneventful and not difficult, and the microscopic examination will confirm the diagnosis of a neural tumor.

Spongioblastoma polare is a glioma which occurs as a rule in the optic nerves, the optic chiasm, or the optic tracts. It consists principally of either bipolar or unipolar spongioblasts. They occur in children or in very young adults, have a slowly developing exophthalmos which at some time begins to increase very suddenly; they show an optic

[1] Private communication, October, 1936.
[2] Kiehle, Arch. Ophth., 15, 686, 1936

neuritis, usually, of the retrobulbar type, retinal hæmorrhages are common, and blindness usually occurs at an early period in the progress of the case. The certain diagnosis of the type of tissue present must be made microscopically.

Neuroepitheliomata are rare in the brain and in the cord, but are the common lesion in the retina. They are made up of primitive spongioblasts which tend to form many rosettes. The retinoblastomata show the least differentiation of the cells, are more malignant, and the rosettes are considered as being made up of primitive rods and cones. Exophthalmos from these cases would mean extension of the tumor mass from the globe through the scleral cribriform plate into the orbit. Surgery, or at least radiotherapy, should have been carried out in such cases before this complication had occurred. (See section on Malignancy.)

Fig 51.—Sphenoidal ridge tumor (Groff, personal communication)

The syndrome described by Groff and Alpers[1] of sphenoidal ridge tumor is not uncommon. It illustrates a form of meningioma of the greater wing of the sphenoid, intra-cranial in origin, and demands extensive neural surgery because of its certain progress. The syndrome as outlined by Groff in his presentation of cases is as follows: (a) primary optic nerve atrophy; (b) defects in the visual field which usually take the form of complete homonymous hemianopia, though it may be quandrantic; (c) paralysis of the third nerve; (d) unilateral impairment of the olfactory nerve, and (e) unilateral exophthalmos are the outstanding signs. Additional symptoms, such as monoplegias, impairment of memory, and disturbances of the pituitary body are observed. Figure 51 shows the characteristic roentgenray findings in these conditions.

Sarcomata, mixed-cell tumors, and carcinomata have all been responsible for unilateral exophthalmos. These cases are of grave prognostic import, however. Occasionally after surgery they continue free from metastases

[1] Arch. Ophth., 15, 163, February, 1936, and Arch. Neurol and Psychiat., 31, 713, April, 1934.

for many years, but many others die early with mediastinal and liver involvement. Figure 52 is a case of primary sarcoma of O'Brien's, illustrating well the fact that sarcomata are more common in the younger patients. Carcinomata occur more commonly in those of later years. The most serious factor in these cases is the early diagnosis in the course of the condition, that a surgical orbit is present, and that it must be explored. Gumma of the orbit might simulate these conditions, but other signs and symptoms are present in this latter condition which are not seen with sarcomatous neoplasms. Both carcinomata and sarcomata have extended from the antrum, from the ethmoid, and from the septum into the orbit. These complications are not uncommon and are often terminal in the case. Metastatic malignancy from the stomach, the adrenals, the kidney, and from the long bones of the body have been reported frequently as the cause of unilateral exophthalmos. These cases, naturally, are recognized as secondary to the primary condition, though this does not in any way change the seriousness of the case. Lowenberg's case of neuroblastoma of the adrenal, and Van Duyse and Marbaix's[1] case of hypernephroma are typical of the rare forms. Many ophthalmologists have seen retrobulbar secondary carcinoma from adenocarcinoma of the stomach, and retrobulbar sarcoma from an osteogenic sarcoma of the tibia, and these are not exceptional.

FIG 52 —Primary sarcoma of the orbit (O'Brien, personal communication)

Figures 53 to 64 are schematic drawings of roentgen-ray photographs illustrating various disturbances in the orbit as the result of malignant changes therein. They are from Thiel's[2] work in this field, included herein. Figure 53 is that of a tumor of the lacrimal gland; Figure 54, one of a sarcoma of the orbital roof; Figure 55, an osteoma of the frontal sinus; Figure 56, a carcinoma of the antrum; Figure 57, one of hemangioma of the left orbit with calcified phleboliths in the left orbit and the left frontal sinus; Figure 58, a retrobulbar neurinoma of the right orbit showing especially thickening of the lesser wing of the sphenoid; Figure 59, the same case but to show the optic foramen with the thickened portion of the lesser wing of the sphenoid and the changes in the temporal margin of the orbit; Figure 60, a case of retrobulbar glioma with enlargement of the left orbit; Figure 61, the same case showing the enlargement of the optic foramen; Figure 62, is a case of meningioma of the lesser wing of the sphenoid; Figure 63, is the same case, but a side view showing the changes in the dorsum sellæ, the hyperostoses, and the calcification present; Figure 64, is a meningioma of the lesser wing of the sphenoid viewed from below.

[1] Arch d'opht, 39, 396, July, 1922.
[2] Thiel, Rudolf, Die Bösartigen Geschwülste des Auges und seiner Umgebung., 1939, Verlag Ferdinand Enke, Stuttgart. (Beihefte der Klin Monatsbl. f. Augenheilk.)

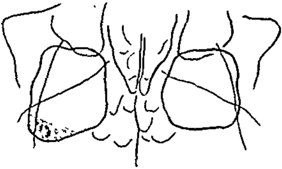


FIG. 53 —Tracings from roentgenograms Lacrimal gland tumor (Figures 53 to 64 inclusive, courtesy of Dr. Rudolf Thiel.)

FIG. 54 —Sarcoma of the roof of the orbit.

FIG. 55.—Carcinoma of the frontal sinus

FIG. 56 Carcinoma of the maxillary sinus

FIG 57.—Hemangioma in the left orbit Widening of the orbital margin and deposits of calcium in the left orbit and left frontal sinus

FIG. 58

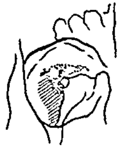


FIG 59

FIG. 58 —Retrobulbar neurinoma Rounded shadow of the tumor in the right orbit, thickening of the bone in the right lesser wing of the sphenoid

FIG. 59.—The same case as Figure 57 to show the optic canal, hyperostosis of the lesser wing of the sphenoid and thickening of the outer temporal orbital margin.

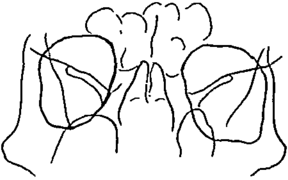
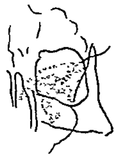


FIG. 60.—Retrobulbar glioma showing widening of the left orbit.
FIG. 61.—Same case as that of Figure 59 to show the enlargement of the optic foramen.



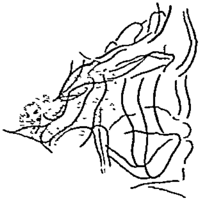


FIG. 62 FIG. 63

FIG. 62.—Meningioma of the lesser wing of the sphenoid; hyperostosis and thickening of the greater wing of the sphenoid as well. Because of the sphenoidal deformity, subsequent deformity of the superior orbital fissure, calcium deposits in the tumor seem to be projected into the shadow of the maxillary sinus.

FIG. 63.—Same case as Figure 61. Multiple calcium deposits, rarefaction of the dorsum *sella, marked thickening of the left anterior clinoid.*

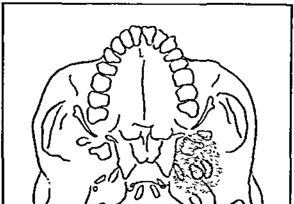


FIG. 64.—Photo from below showing widening of foramen rotundum and foramen ovale, as a result of a meningioma of the lesser wing of the sphenoid.

TREATMENT OF ORBITAL CONDITIONS

In the treatment of the exophthalmos of toxic goiter, in the unilateral as well as in the bilateral varieties, retrobulbar tissue resections are not recommended. The correction of the lagophthalmos, the prevention of prolapse of the globe, with impending strangulation of the eyeball, and the procedures for progressive malignant exophthalmos must be considered.

The external orbitotomy of Shugrue's, as presented by Moran, at the 1937 meeting of the American Medical Association, is apparently a most satisfactory orbitotomy for exploratory surgery and for decompression. Shugrue's technique is as follows: the incision begins at the posterior end of the zygomatic arch just in front of the tragus, ascending vertically

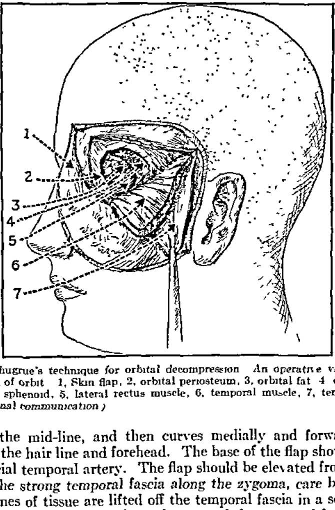


FIG 65 —Shugrue's technique for orbital decompression An operative view of lateral decompression of orbit 1, Skin flap, 2, orbital periosteum, 3, orbital fat 4 cut surface of great wing of sphenoid, 5, lateral rectus muscle, 6, temporal muscle, 7, temporal fascia (Moran, personal communication)

almost to the mid-line, and then curves medially and forward to the junction of the hair line and forehead. The base of the flap should include the superficial temporal artery. The flap should be elevated from the rear to expose the strong temporal fascia along the zygoma, care being taken that all planes of tissue are lifted off the temporal fascia in a solid group, particularly anteriorly where the malar part of the temporal fascia is covered by a dense area of fatty areolar tissue; otherwise the nerve supply to the orbicularis oculi and frontalis muscles may be injured. The temporal fascia is cut in a crescent manner somewhat below and anterior to the skin incision. The temporal muscle is now separated from its bony origin and reflected downward with the fascia. The overhanging lip of the arch formed by the malar and frontal bone may be removed with bone forceps. An

opening is made into the lateral wall of the orbit just below and behind the fronto-malar suture. The outer wall of the orbit formed by the zygomatic and frontal bones is now removed. Posteriorly, the outer table of the greater wing of the sphenoid is removed with a chisel, exposing a thick cancellous layer. This is curetted out (in a manner similar to mastoid cells), exposing the shiny inner plate of the orbital surface of the sphenoid. This, in turn, is carefully bitten out. Bleeding is controlled with bone wax. Now the whole area may be enlarged downward to the upper border of the inferior orbital fissure. Care must be taken not to enter the skull through the sphenoid bone, nor to injure the maxillary nerve at the lower part of the operative field. The orbital fascia is now exposed and incised in all directions. Should more room be desired a large trephine opening may be made in the frontal bone and widened laterally and below, with removal of the roof of the orbit almost to the optic foramen. The temporal muscle and fascia are now loosely closed—permitting room for drainage. The skin is closed with or without a drain. Figure 65 is the original sketch of the surgery. Figure 66 illustrates, schematically, the superior and front views of the bone removed in this operation.

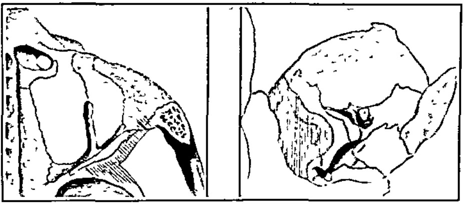


FIG 66.—Superior and frontal views of areas of bone resection in the subzygomatic decompression.

The advantages of this technique apparently rest in the wide decompression possible without the necessity of opening into the cranial cavity. Naffziger's[1] transfrontal decompression of the orbit is preferred in many instances; there is but little difference, however, in the degree of decompression obtained. This procedure, however, is one which should be done by the neuro-surgeon, and not by an ophthalmologist, though that technique of Shugrue's can and should be done by the ophthalmologist himself. Further procedures as to restricting tarsorrhaphy are given in detail under the surgery of the lids.

Traumatisms.—Fractures of the orbit should be reduced at the time the injury occurs and before solidification has developed. Avertin anesthesia is necessary. The immediate repair of the soft parts is by no means so important. When solidification has occurred the depressed fractures can be corrected only by cartilage implants, and then for cosmetic purposes alone. Gillies has reopened a depressed fracture of the orbit, and elevated

[1] Arch. Ophth., 9, 12, January, 1933.

FIG 67.—Roentgen-ray of fracture, outer wall of the right orbit before reduction

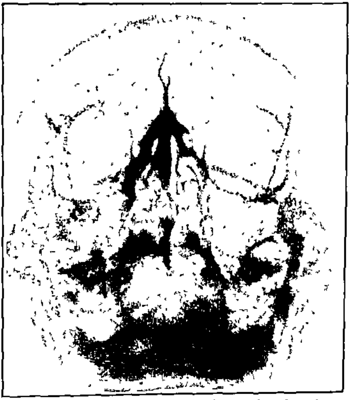


FIG. 68.—Roentgen-ray of fracture, outer wall of the right orbit, after reduction. (See Figure 67.)

the floor of the orbit by packing within the maxillary sinus. A depressed fracture of the orbital rim at the outer zygoma-malar junction can be reduced through a small vertical incision posterior to the posterior edge of the zygoma, and with the introduction of a stout, blunt chisel into the temporal fossa behind the zygoma, a great amount of leverage can be exerted in this way to replace the fragments. Manipulation with the fingers upon the skin surface will assist.

Frequently a short, stout, blunt periosteal elevator can be placed in the outer canthal angle and sufficient leverage obtained thereby to dislodge impacted fragments of the bony orbit and reduce the fracture in this way without being compelled to open the skin. These are usually driven down into the orbit by the impact. They can be reduced rather readily in this manner. The fractures which occur at the outer inferior angle can be reduced similarly. The eyeball must be protected from damage. The amount of trauma which is done to the conjunctiva is of no great clinical importance. Figures 67 and 68 are of a simple fracture of the orbit resulting from a direct blow to the rim of the orbit, reduced by leverage with a stout periosteal elevator applied against the lateral wall of the orbit. The slight trauma to the conjunctiva from the manipulation recovered wholly within forty-eight hours. Fractures of the floor of the orbit can be corrected by a similar incision high in the buccal cavity directly on the bone of the malar prominence with a similar stout, broad, blunt chisel used as a lever for reducing a fracture there, and for restoring the fragments to their original normal alignment. Occasionally by passing the elevator high up in the buccal fold under the skin, one can get adequate purchase against bone fragments there so that a reduction can be achieved without an open incision. Naturally this is to be preferred. The same surgical principles apply here as elsewhere; a fracture which can be reduced through the closed method recovers much more readily and with fewer secondary complications than those cases in which an open reduction is used.

Depressed fractures of the malar, if relatively recent, can be frequently corrected early in the course of the case. McIndoe[1] states that in contradistinction to the nasal ethmoid maxillary fracture, treatment should, whenever possible, begin with an attempt at replacement. The operation is of the same type as that used for impacted malar fracture, but more strenuous in degree. It is directed towards producing sufficient disimpaction and elevation of the malar maxillary compound to bring the infra-orbital plate to its correct level. If comminution is extreme and bone loss marked, it is sometimes possible by a block of stent in the antrum to create an infra-orbital shelf of fragments of bone which can be supported, until consolidation occurs. The triple approach is usually necessary. If elevation of the globe can be satisfactorily accomplished so that diplopia is overcome, then any other deformity of contour becomes of secondary importance and can be concealed by the insertion of fat, muscle, or cartilage at a later date. If, on the other hand, elevation of the globe fails by these means and diplopia persists, considerable improvement can be brought about by inserting between the periosteum and the infra-orbital plate strips of costal cartilage until the level of the orbital floor is raised to the requisite height.

[1] Surg., Gynec. and Obst., 64, February 15, 1937.

Fractures of the medial wall of the orbit had best be referred to a capable rhinologist. These are so frequently compounded into the ethmoid and into the sphenoid that they early become rhinological problems. Fractures of the roof of the orbit, if they involve any portion except the orbital ring, should be referred to a neuro-surgeon, in that they are, by reason of their position, also a fracture of the frontal fossa.

Penetrating wounds of the orbit, from projectiles, usually mean extensive débridement with enucleation or evisceration, either immediately, if the patient's condition will allow, or later as a form of reconstructive surgery. Axenfeld,[1] has discussed in detail these gunshot wounds. The point of entrance may be in one eye with the destruction of both orbits, the point of exit being upon the opposite side of the head. These gunshot wounds with the missle retained, must be handled with a biplane fluoroscope and by orbital wall resection or some modification of this. The magnet, in magnetic foreign bodies, will be of great assistance. The operator must be careful not to destroy, as a result of his surgery, intact nerve and muscle tissues, though lacerations and ruptures of the extra-ocular muscles are unfortunately not correctable at the time of the injury and the initial surgery. Because of this the later surgery is essentially for the correction of resulting defects. Traumatic evulsion of the globe with blindness may need an enucleation if this can be done immediately. If secondary infection has occurred, evisceration of the eyeball is the operation of choice.

The surgery of aneurysms, whether arterial or arterio-venous, is a problem for specialists in vascular surgery. The ophthalmologist, however, is a rather necessary part of a team for the correction of these cases At the time of the initial ligations it is necessary to watch the retinal vessels with an ophthalmoscope, and to warn the surgeon to stop short of a complete closure of the central artery of the retina. This applies even in fractional ligations. Naturally it does not apply to the ligation of the tributaries of the carotids. It has been found that these must also be ligated if success is to be achieved, because of the development of reserve and back flow and the nullification of any ligations proximal to these branches. Rather recently, the roentgenologists have reported satisfactory results in the treatment of intra-cranial internal carotid-cavernous sinus aneurysms by deep roentgen-ray therapy.

ACUTE AND CHRONIC INFLAMMATORY CONDITIONS

Acute inflammatory, and chronic inflammatory osteitis, and osteomyelitis are to be considered. The acute suppurative processes, if they do not arise from direct trauma to the wall of the orbit, are usually the result of perforations from the nasal accessory sinuses.

Acute Inflammatory Processes.—*In considering the source or origin of* the infection, the first task is a brief review of a part which the sinuses may play in the development of these complications. The maxillary sinus, by reason of its remote distance from the orbit and from the cranial cavity, is the least at fault. Still, Bonninghaus[2] in a critical research on the intracranial complications of sinus pathology, found in a series of 52 such cases

[1] Handbuch der Arztlichen Erfahrungen im Weltkriege 1914–1918, Prof. Dr Otto von Schjerning.
[2] Handbuch der Spec. chir , 2d ed , 1914, Katz, Preysing Blumenfeld.

(1 cerebral abscess, 27 cases of meningitis, and 24 cases of cavernous sinus thrombosis) from 2 to 9 cases which originated either from the maxillary sinus wholly or in which the maxillary sinus played a large part. The frontal sinus, in spite of its contiguity to the brain, is also only rarely to blame, though rather more so than is the maxillary sinus. (Cranial osteomyelitis, and extension into the meninges and to the brain substance through this, are naturally excluded.) Complications, otherwise, are most uncommon from perforation of the bony walls, but occur usually by means of the venæ perforantis. Subdural and extradural abscesses, leptomeningitis, thrombophlebitis and abscesses of the cortex of the brain substance have all been described. The sphenoid sinus is the next most important of the sinuses in etiological importance. Yerger's[1] analysis of this sinus in its intra-cranial relationship is rather complete. In the years 1911—1920 there were 393 cases of suppurative sinusitis treated at Cook County Hospital. Yerger found 11 cases, or 2.8 per cent, of these to be sphenoidal, and of these 11 cases, 7 developed intra-cranial complications. Yerger stated that, while the sphenoidal sinus was the least frequently diseased of the nasal sinuses, it caused the greatest proportion of intra-cranial complications. In this he must differ with many other rhinologists, though the sphenoidal sinus is rather likely the most common cause of cavernous sinus thrombosis. This relationship is quite important, and in this it is similar to that rôle which the mastoid and the labyrinth play to the lateral and other immediately continuous and contiguous venous sinuses. In all of these cases of thrombosis of the venous sinuses, it seems that localized vessel wall septic infiltration first occurs, adherent clots develop at these sites of inflammation, continued layers of clot form upon these, one after the other, until the lumen of the vein is closed; and, last, because of the bacterial invasion, necrosis and liquefaction of this coagulum occur, with the formation of septic emboli, and general systemic pyemia as the end-result. In the similarity mentioned, a thrombotic process of otitic origin may advance also to a most extensive degree. The ethmoidal sinus is considered as being most commonly at fault in the causation of the various intra-cranial complications. Apparently the infectious process perforates the lamina cribrosa, and enters the subdural space in this manner. In contradistinction to the frontal sinus, the meningeal complications seem to occur most frequently with the acute phase of suppurative sinusitis of the ethmoid rather than during the chronic course of such infections. In this it is similar to the sphenoidal sinus.

The various oculo-orbital signs and symptoms which may appear, in themselves prove nothing as to whether or not there is an extension of the infection into the cranial cavity. They are known to appear, however, in those cases of sinusitis which become complicated by intra-cranial pathology, hence they acquire an important diagnostic value. In general (and this applies to otitic as well as to rhinologic etiology), the certainty of a developing intra-cranial infection dates from the appearance of vomiting, of impaired memory and attention, emotional instability, disorientation—to the development of coma, transient attacks of aphasia and of similar discrete functions, even though the centers for the functions themselves may not be involved; and, last, the appearance of epileptiform convulsions.

[1] Illinois Med Jour., 43, 304, April, 1922, and Eye, Ear, Nose, and Throat Monthly, 3, 385, August 1924

It is remarkable, however, how long the interval may be in these cases, at times, from the onset of the peripheral infectious focus to the formation of the intra-cranial complications. The ocular complications seen should appear in the extra- and intra-ocular muscles, including nystagmus, the oculo-motor paralyses and disturbances of the conjugate and associated ocular movements; in the fields of vision and in central visual acuity; in the ocular fundi, especially in the condition of the optic nerve papillæ and of the retinal vessels; in certain changes in the extra-ocular anatomy, as the position of the eyeball in the orbit, pain upon digital pressure to the eyeball, edema of the lids, and lagophthalmos from central types of facial paralysis; and, last, in various less common conditions, as visual aphasia and hemiplegia accompanied by homo-lateral homonymous defects in the fields of vision.

These conditions must be drained early in their course either through intra-nasal surgery or through the lids with a transorbital incision through the peri-orbita, or both may be used, if desired. The important thing is to establish the drainage, and if the surgery by the rhinologist is not sufficiently free, then the ophthalmologist must incise further and drain

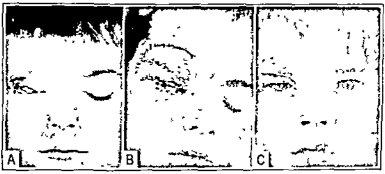


FIG 69.—Tuberculosis of orbital rim (osteomyelitis) *A*, one year after sanitarium hospitalization; *B*, correcting flap before sutures were removed, *C*, condition when patient was returned to the sanitarium

externally. Complications are too frequent as it is without tolerating unnecessary delay. The lid incision for these conditions should lie in the orbito-palpebral fold, pass directly backward, outward, along the roof or the lateral wall of the orbit, and the peri-orbita incised, the point and the edge of the scalpel cutting against the bony wall of the orbit. If the direction of the knife is carried as a chord to the concavity of the orbital cavity, no vital structures will be damaged and drainage can be obtained. The incision may be widened by spreading it with hæmostatic forceps with their points held against the bony wall of the orbit. Drains used should be of rubber tissue or oiled silk and not of gauze, for these latter most effectively cork up the infection and nullify the purpose for which the incision was made. Hot saline compresses and copious irrigation seem to assist in the postoperative recovery. Careful and repeated roentgen-ray studies are necessary to be certain that an osteomyelitis is not developing, or is not already present. It seems that rhinologists are assuming a more conservative attitude toward the treatment of suppurative osteomyelitis from sinus pathology than was earlier present. Death has occurred repeatedly in these cases from over-enthusiastic and premature surgery. Osteomyelitic

sequestra do not need an immediate sequestrectomy. This can be delayed, often, until some of the acute changes have receded. This applies to a tuberculous osteomyelitis as well. Even sanitarium treatment should precede surgery in such instances.

Chronic Inflammatory Processes.—Tuberculosis and various mycotic infections are most commonly at fault here. The latter of these was covered sufficiently under the earlier discussion of unilateral exophthalmos. Drainage, the laboratory diagnosis, and the use of iodides are essential. Tuberculosis and syphilis are not dissimilar in their earlier signs and symptoms. With syphilis, the positive serology, the absence of sinuses and of fistulæ, and the early hyperplasia of the bone, are outstanding; while with tuberculosis, the formation of sequestra and of fistulæ is characteristic. Figure 69, *A*, *B*, and *C*, is the external appearance of such a case. In such instances sanitarium treatment with heliotherapy and the other supportative

Fig. 70.—Roentgen-ray of Tb osteomyelitis of the lateral wall of the orbit. (Lipiodol shows the multiple fistulæ and tracts.)

measures of tuberculosis are necessary, for the plastic defect cannot be corrected until the bone process is cured. Figure 70 is an osteomyelitic process of the lateral wall of the orbit, demonstrated to be tuberculosis by guinea-pig inoculations. The lipiodol injections here show the multiple fistulæ which developed in the depths of the bony orbit. Roentgen-ray evidence of a sequestrum means ultimately a sequestrectomy. The sequestrum seen in the outer wall of the orbit (illustrated in Figure 71), which resulted from a birth trauma, was well encapsulated, and this sequestrum would not have been removed had it not been necessary to do an orbital wall resection because of a retrobulbar neurofibroma.

Syphilitic osteitis is not a surgical problem, and, therefore, can be dismissed from consideration here. Malignancy of the orbit usually develops from superficial epitheliomata at the outer angle of the orbit or by extension from the nasal accessory sinuses, above, medially, or below. Figure 72

A and B, is such an instance wherein a thrice recurrent epithelioma finally demanded a resection of the entire lateral wall of the orbit, posteriorly from the root of the zygoma and anteriorly to the zygoma-frontal junction above, and to the zygoma-malar suture line below. The major portion of

FIG 71.—Roentgen-ray of a sequestrum in the outer wall of the orbit from a birth traumatism

both lids was resected at the same time as well as the entire external angle of the conjunctival cul-de-sac, both upper and lower fornices. In such instances the soft tissue can be dissected widely, well into the normal tissue. The bone dissection should also start in healthy bone and the diseased bone lifted out entirely. These resections should be followed by further roentgen-ray therapy.

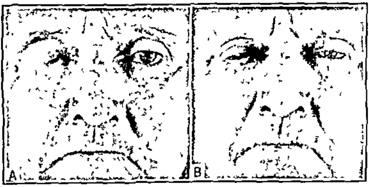


FIG. 72 —Orbital wall malignancy· A, after orbital wall resection; B, six months later after canthoplasty

PLASTIC CORRECTION OF THE LATE BONY DEFECTS OF THE ORBIT

In these cases the surgeon should construct a mold of paraffin or dental stent or wax of such a size and shape that when fitted over the soft tissues it corrects the bony defect. This can then be cast by a dentist, in artificial stone, and the model taken into the operating room as a pattern for the necessary cartilage graft. Figure 73 is illustrative of such a case. The patient had a shotgun wound of the orbit with a loss of the outer rim and

in part, the outer wall of the orbit. The black line shows the distance on the normal side from the rim of the orbit to the root of the ear. The costal cartilage graft was cut, trimmed to size and shape and sutured into position according to such a pattern with the satisfactory result seen. The details of the technique are illustrated as well.

The graft is to be removed, under general anesthesia, from the right side of the chest naturally, considering the position of the heart. The incision should be roughly concave-convex, with the concavity crossing the junction

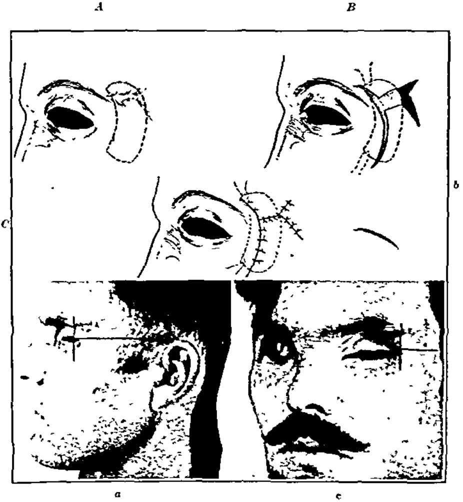


FIG 73 —Orbital wall defect a, before correction, b, details of the correction (A, defect and the position for the graft, B, graft in place for suturing, C, sutures inserted); c, completed result

of the sixth and seventh ribs, extending from the ensiform process to the continuation of the nipple line. The fascia and the ascending fibers of the abdominal rectus are then divided vertically. The superficial fascia overlying the rib is incised and the cartilaginous portions of the sixth and the seventh ribs brought into view. The approximate shape of the pattern is blocked out on the surface of the rib, cutting through the perichondrium and into the cartilage for a distance equivalent to the thickness of the graft desired. The graft is then lifted from its bed by one of the cartilage gouges illustrated in Chapter I. The graft is placed in warm physiological saline

solution when removed, all bleeding is stopped, and the site closed. The fibers of the pectoralis muscle are sutured first, and the fascia in a second layer, both with No. 2 chromic catgut. The skin can be closed with dermal sutures. An adhesive tape dressing is placed over a gauze dressing similar to that which would be applied for an uncomplicated fractured rib. The graft is then cut to the shape of the pattern, but all perichondrium present

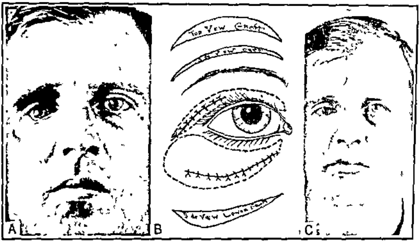


FIG. 74.—*A*, before correction, *B*, details of the graft, *C*, after correction

must be conserved, though if the graft is to be placed subperiosteally this is not so important. If, however, it is to be mortised into a bony defect, the conservation of the perichondrium is most important. The bed, for the preparation of the graft, is carefully formed with sharp dissection and with the mallet and chisel as these are necessary. The graft should fit accurately, and should be sutured into place to the contiguous periosteum Such

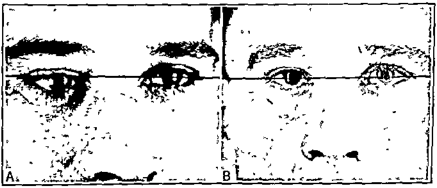


FIG. 75 —*A*, before, and *B*, after correction Line shows amount of elevation obtained

sutures must hold it firmly; if not it may be sutured with fine silver wire of about a No. 24 gauge through holes drilled in the contiguous normal bone. These silver wires in position are the only means of identifying roentgenologically a cartilage graft used for a reconstruction. Figure 74, *A*, *B*, and *C*, are the details, and the before and after illustrations, of a cartilage repair of both the floor and the roof of the orbit as a result of a gunshot wound.

In this case sufficient periosteum was still present so that the wedge-shaped scales of cartilage could be buried under the remaining periosteum—precisely as one would drive a wedge into a log, parallel to the line of its wood fibers. Figure 75 is a similar correction of an old depressed fracture of the floor of the orbit with a rather marked ptosis of the eyeball. This was elevated with a scale of bone beneath the periosteum of the orbit raising the orbital contents appreciably, as can be seen. In these instances the periosteum of the inferior lip of the orbit is incised and elevated, the wedged-shaped graft is then placed beneath the periosteum and the bone, with its thickest margin externally. This external thick base of the wedge should be covered with perichondrium. Atrophy of the floor of the orbit from neurofibromatosis may be corrected similarly. In placing these grafts into the floor of the orbit whether wedge-shaped, as in that necessary for Figure 75, or as flat scales, in those in Figure 74, it is important that they be immobilized. The skin incision line must be so arranged that it does not lie immediately above the graft. Orbicularis fibers usually can be sutured above the graft as a mobile soft tissue flap with No. 3-0 plain catgut, and the skin closed subsequently with dermol and with this suture line in a somewhat different direction. Careful technique and the maintenance of a rigid sepsis is necessary. In securing the graft, routinely, the chest wall should be roentgen-rayed before a cartilage graft is removed, a careful history taken and physical examination made to eliminate the possibilities of old adhesions from a preëxisting pleuritis. If the pleural cavity is perforated, while removing a graft, the perforation must be plugged with a tongue of muscle tissue, and the chest immobilized with adhesive.

Pierce, who has done much work in cartilage plastics has used a great amount of cadaver cartilage. This must be removed before embalming, under surgical asepsis, and the cartilage stored in a refrigerator at about 38° F., in an aqueous solution of 5 per cent merthiolate. It can be left in this manner for several months. The perichondrium, in all stored cartilage, should be removed before storage.

Cartilage and corneal tissue are perhaps the only grafts which can be used with success as an isograft. All other grafts are likely to result in failures unless they are homografts.

INFLAMMATORY PROCESSES WITHIN THE ORBIT

These have been considered, in part, under the discussion of pathological changes in the orbital walls themselves. Retrobulbar cellulitis, retrobulbar phlegmon and retrobulbar abscess are conditions which demand drainage. Conditions which arise from the ethmoid, with free pus in the orbit, must have early intra-nasal ethmoidal drainage as well. The differential diagnosis of orbital abscess and of pseudo-tumor is not simple, as Fry[1] and Shoemaker[2] separately pointed out. Exophthalmos, with swelling of the lids, developing immobility, with fundus pathology, and with a septic temperature, must be seriously considered. Their presence, however, when not accompanied by nasal accessory sinus suppuration is important in the differentiation of inflammatory pseudo-tumor and phlegmon and abscess.

[1] Penn. State Med Jour., October, 1936.
[2] Modern Ophthal., Ball, ed. S., Philadelphia, F. A. Davis Company, 1913.

Cellulitis is occasionally properly incised and no suppuration uncovered. Drainage should be established in these, however, just the same. Repeatedly, the streptococcus is cultured from the depths of such incisions. It is rather likely that the surgeon has incised for drainage before pus has formed. The greatest error is not premature incision and drainage, but delayed incision and drainage.

The pathology of cavernous sinus thrombosis has been covered adequately by several authors, notably by de Schweinitz and by Eagleton. Cavernous sinus thrombosis can recover after enucleation of the eye, primarily proptosed, with exenteration of the orbital contents to the apex of the orbit, and by obtaining drainage through an opening there into the cavernous sinus. Eagleton's treatment[1] considers an attack upon these conditions through drainage, not only after evisceration of the orbit and drainage of the cavernous sinus but also combining with this, ligation of the external and internal carotids just above the bifurcation with ligation of the ascending branch of the external carotid as well. Various rhinologists have also recommended ligation of the internal jugular vein as well, to prevent systemic dissemination of septic emboli. These cases are serious, but recoveries do occur with this radical treatment. In the differential diagnosis of an orbital phlebitis as compared with an early cavernous sinus thrombosis, the former remains unilateral, and there is a definite blueness to the vessels of the conjunctiva because of venous stasis, many of which run parallel with the axis of the globe. Eagleton believes[2] in such a case a pocket of pus may be found by multiple punctures outside or inside the muscle cone, or according to Butler[3], after the division of one or both tarsal ligaments. Lawson[4] believes that this surgery may convert a semi-quiescent phlebitic infection into an actively advancing one.

Suppurative tenonitis, which develops occasionally postoperatively, especially after muscle surgery, demands the removal of all sutures and the establishment of free drainage. Copious irrigations, with a warm physiological salt solution should be combined with hot compresses, some of these infections may develop from the catgut used, as it is well known that some infected catgut is on the market. An eyeball can be lost as a result of such an infection.

An orbital mucocele demands rhinological surgery, and is one of the few instances wherein extensive surgery is indicated on a nasal accessory sinus.

An orbital exostosis, usually hyperplastic in nature and the result of chronic ethmoidal pathology, can be removed by an incision at the inner angle of the orbit, following the line of the orbito-palpebral fold, above and posterior to the dome of the lacrimal sac. With a brain spatula, the orbital contents can be retracted temporally, the periosteum incised and elevated, and the exostosis cleanly removed with a small chisel and a mallet. The dura may present and must not be opened.

RETROBULBAR SPACE TAKING LESIONS

The greatest difficulty in the diagnosis of a retrobulbar space taking lesion is not the presence of such a lesion but the type of tissue there.

[1] Trans. Am. Acad. Ophthal. and Otolaryngol., p 96, 1934.
[2] Cavernous Sinus Thrombosis, New York, Macmillan Company, 1926.
[3] Trans. Ophthal. Soc of the United Kingdom, 1923.
[4] Ibid., 1895.

Figure 76 is a massive retrobulbar tuberculoma, a lesion which can be readily palpated. The chronicity of such a case when combined with the general symptoms should suffice for the diagnosis of a non-malignant mass. The exophthalmos seen in myelogenous leukemia will be correctly diagnosed by the blood picture. The roentgen-ray is sufficient for the diagnosis of an osteoma. A myxosarcoma, however, which lies within the muscle cone can be diagnosed only by the slow progress of the exophthalmos, perhaps its palpation deep in the orbit either with the fingers or by means of a glass rod, and by the elimination of all other possible causes for the exophthalmos. The position of the lesion can be estimated approximately by the roentgenogram, by the direction of the proptosis, and at times by an external rectus. One case of retrobulbar sebaceous cyst ruptured spontaneously through the orbital plate of the ethmoid, the diagnosis being made as a result of this.

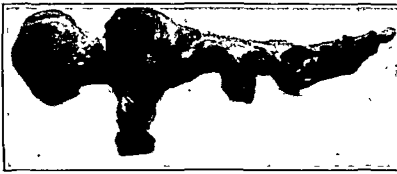


FIG 76 —Retrobulbar tuberculoma Nodules adherent to the eyeball and to the muscles

In so far as surgery of the orbit is concerned, the author would call attention to Benedict's rules relative to this.[1] His paper is abstracted in part, for not only is it the author's conception, but also it is so ably presented.

Surgical treatment of bony tumors of the orbit includes intimate knowledge of the structure of the orbit and of the physiology of the eye. Because of accessibility, surgical approach to the (an) osteoma is usually through the orbit. Furthermore, attacking the tumor near its base by the most direct route facilitates removal and sometimes avoids trauma in the bed of the tumor. If the tumor can be removed from its bed by an approach through the orbit, there is little danger of meningitis or of intra-cranial infection, even though the tumor should lie in contact with a large area of dura The approach through the cranial cavity, as practiced by some neurosurgeons, has led to an excessive mortality rate which I believe could have been avoided if the tumors had been removed through the orbit. Small tumors invading the orbit from the medial side may be removed with the lateral nasal wall, through the nares. There is a group of softer bone tumors which does not belong in the category of exostosis and of osteoma. Because they involve the bones of the face, they are referred to as *osteomata*, although they are of entirely different origin and character. I refer to inflammatory thickening of the bones of the face which gives rise to facial asymmetry and occasionally to proptosis through the encroachment on the orbit. One or more bones of the face may be involved, in contiguous enlargement, or the enlargement may be confined to a single bone. Occasionally, multiple osteomata of this type involve widely separated bones of the face and head. Enlargement in this type of bone disease consists of proliferation and hypertrophy without material change in the structure of the bone. They are vascular, usually fragile thickenings of the central portion of the bone, with slight to moderate increase in the eburnation of the surface. They grow slowly and

[1] Clinical Congress of the American College of Surgeons, October, 1933.

rarely produce blindness. If the sphenoid bone is involved, the orbital foramen may be distorted and blindness may result from pressure on the optic nerve. Osteomata of this type are most commonly found in the frontal, maxillary, and sphenoid bones. Surgical intervention, fortunately, is rarely indicated. Bony tumors of the orbit can be removed only by surgical intervention. Bearing in mind that osteomata usually have small pedicles, the logical method of approach would be the most direct route to the base of the tumor. Osteomata usually are rounded on the nasal or superior aspect of the orbit, and usually are situated posterior to the equator of the globe, pushing it forward, downward, and outward. Since they lie underneath the peri-orbita, it is convenient to approach the tumor by means of incision through the skin and the periosteum, anterior to the surface of the tumor. Working toward the suspected situation of the pedicle, a periosteal elevator or a chisel may be introduced along the side of the tumor, and by gentle, rocking pressure the tumor, with its pedicle, may be dislocated at the base, or, if the pedicle is small, it may be divided by a few sharp blows with hammer and chisel After the pedicle or base has been divided, it may be possible to remove the tumor in one piece by gentle manipulation. If, however, the tumor should be large and wedged behind the frontal bone, it may be advisable to divide it and remove it in small pieces Because the roof of the orbit frequently has been eroded, caution should be exercised in the separation of the superior surface of the tumor, which is often in contact with dura where adhesions may have taken place. It is advisable, if possible, to separate the superior and posterior surfaces of the tumor from the adjacent tissues with a blunt instrument. If the dura has been lacerated in the separation of the tumor from its bed, the denuded area may be covered by suitable membrane, after which the cavity is filled with normal saline solution and the cutaneous wound sutured water tight.

From the standpoint of surgical anatomy there are three areas about the orbit which are concerned in planning surgical procedures for removal of tumors First, there is a potential space between the peri-orbita and the bony wall The peri-orbita, for the most part, is easily detachable so that there is a potential space between it and the bone. It is firmly attached at the rim of the orbit, where it becomes continuous with the periosteum covering the bones of the face At the apex it is closely adherent to the sheath and upper part of the optic nerve. It is firmly fixed at the lacrimal fossa, at the sutures and various fissures and foramina Subperiosteal tumors, such as osteomata, which invade the orbit from the paranasal sinuses, as well as malignant tumors of the soft tissue, can be approached most easily in the following manner: An incision parallel with the superior orbital margin is made through skin and periosteum from the supra-orbital notch to the temporal side below the region of the lacrimal fossa. The incision should go to the bone, cutting the periosteum a few millimeters above the rim of the orbit The periosteum is then separated to the orbital rim, where it joins the peri-orbita With some care the peri-orbita can be separated from the bony rim of the orbit, allowing an instrument to be introduced into the potential subperiosteal space, and the peri-orbita separated from the bone on the nasal, superior, and temporal walls, well back into the orbit. The globe and other orbital contents can then be depressed, leaving sufficient room for necessary surgical manipulation.

The second surgical space to be considered is the area between the peri-orbita and the muscle cone. In this area will be found tumors of the lacrimal gland, metastatic sarcomata, carcinomata, primary tumors of the orbital connective tissues, angiomata, endotheliomata, and a wide variety of benign and malignant neoplasms. The method of operation for removal of tumors in this space should be chosen after consideration of the probable difficulties to be encountered in the separation of the tumor from adjacent tissues and of the deformities or disfigurement resulting from the operation. Tumors in this surgical space, that are situated well anteriorly, usually are palpable through the outlet and are movable, while on the other hand, tumors of the lacrimal gland and tumors that are infiltrating rather than encapsulated are likely to be fixed and firm to palpation. In dealing with fixed, firm tumors in the orbit one cannot determine by palpation through the lids the surgical space in which the tumor may be situated or the character of the tumor. Large, soft tissue tumors have been mistaken for osteomata and surgical intervention deferred, allowing blindness to occur, when early surgical intervention would have prevented it. This mistake need never be made if good roentgenograms

of the orbit are studied stereoscopically. More than three-fourths of the soft tissue tumors that occur in this intermediate surgical space can be removed with a minimum of disfigurement through the incision described for removal of tumors in the subperiosteal space. After the peri-orbita has been separated, as has been described, the globe and other orbital contents can then be depressed, leaving sufficient room for digital exploration. Tumors can be palpated, for situation and size, before the peri-orbita is opened so that the field is uncomplicated by protruding fat. The peri-orbita can be incised in the radial (antero-posterior) direction in a position most favorable for removal of the tumor with the least danger of injuring the normal ocular structures. It is seldom necessary to provide drainage after removal of an orbital tumor, so the peri-orbita may be closed, the periosteum resutured above the orbit, and the external wound closed for primary healing. The wound should be supported by a snugly fitting bandage.

The third surgical space includes the region within the muscle cone. In this region are found tumors of the optic nerve and its sheath, vascular tumors, and neoplasms of the globe that have perforated the sclera. Tumors within the muscle cone usually cause direct protrusion of the eye, with little or no lateral displacement. They are not palpable through the outlet and are not discernible in roentgenograms. They usually produce choked disk and intra-ocular vascular distention. Tumors of the optic nerve and sheath usually lead to visual disturbances early in their growth, a condition which does not obtain for most tumors of the soft tissues of the orbit without the muscle cone. It may be possible to remove a tumor of the optic nerve without sacrificing the globe. For such purposes one has the choice of two routes. The most desirable from the standpoint of accessibility and minimal disfigurement is by the subperi-orbital route described. Because of the peculiar configuration of the bony orbit, it may be more desirable, however, to enter the orbit through a resection of the lateral wall as provided by the Kroenlein operation.

The uncapping of the roof of the orbit, through a transfrontal approach, as outlined by Grant and Frazier, by Edson, and by others, is a satisfactory orbital approach for lesions which lie to the medial side of the optic nerve. According to Rollet,[1] the marginal route is far preferable for removing deep orbital tumors. If the tumor is not apparent and its site not discernible, the operation required may be termed an exploratory extra-aponeurotic external orbitotomy. The different stages are as follows: (1) Suture of the lids with silk, which preserves the cul-de-sac, facilitates deep examination and prevents corneal ulcer; (2) curved external incision at least 3 cm. long, starting from the end of the eyebrow, and going to the bone. The anterior structure is then divided close to the orbital border; (3) digital exploration of the orbit, with avoidance of injury to the enclosed fat, muscles, vessels and nerves; (4) removal of the tumor and suture. A space is thus entered which contains no important vessels, muscles or other structure, and in which tumors commonly develop. This marginal route can be followed quite far externally.

External orbitotomy combined with an orbital wall resection is occasionally indicated. The author's experience with the Kroenlein technique for temporal resection of the external orbital wall has been wholly satisfactory. General anesthesia is necessary. The eyebrow should be shaven, as well as the hair, from the temporal region. Several different skin incisions may be made to approach the orbital wall. The original Kroenlein incision was curved with the convexity forward, 7 to 8 cm. in length, beginning 1 cm. above the angular process at the frontal bone and ending at the middle of the zygoma. Terrien's incision is that of a Y lying upon its side, the two short arms over the orbital margin, the long arm continued posteriorly and horizontally to the midline of the zygoma. See Figure 77 *A*, for the site

[1] Lyon chir., 19, 760, December, 1923.

of the orbit are studied stereoscopically. More than three-fourths of the soft tissue tumors that occur in this intermediate surgical space can be removed with a minimum of disfigurement through the incision described for removal of tumors in the subperiosteal space. After the peri-orbita has been separated, as has been described, the globe and other orbital contents can then be depressed, leaving sufficient room for digital exploration. Tumors can be palpated, for situation and size, before the peri-orbita is opened so that the field is uncomplicated by protruding fat. The peri-orbita can be incised in the radial (antero-posterior) direction in a position most favorable for removal of the tumor with the least danger of injuring the normal ocular structures. It is seldom necessary to provide drainage after removal of an orbital tumor, so the peri-orbita may be closed, the periosteum resutured above the orbit, and the external wound closed for primary healing. The wound should be supported by a snugly fitting bandage.

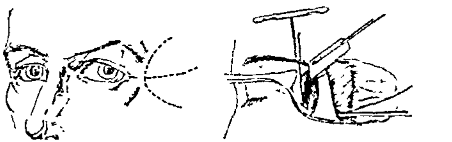
The third surgical space includes the region within the muscle cone. In this region are found tumors of the optic nerve and its sheath, vascular tumors, and neoplasms of the globe that have perforated the sclera. Tumors within the muscle cone usually cause direct protrusion of the eye, with little or no lateral displacement. They are not palpable through the outlet and are not discernible in roentgenograms. They usually produce choked disk and intra-ocular vascular distention. Tumors of the optic nerve and sheath usually lead to visual disturbances early in their growth, a condition which does not obtain for most tumors of the soft tissues of the orbit without the muscle cone. It may be possible to remove a tumor of the optic nerve without sacrificing the globe. For such purposes one has the choice of two routes. The most desirable from the standpoint of accessibility and minimal disfigurement is by the subperi-orbital route described. Because of the peculiar configuration of the bony orbit, it may be more desirable, however, to enter the orbit through a resection of the lateral wall as provided by the Kroenlein operation.

The uncapping of the roof of the orbit, through a transfrontal approach, as outlined by Grant and Frazier, by Edson, and by others, is a satisfactory orbital approach for lesions which lie to the medial side of the optic nerve. According to Rollet,[1] the marginal route is far preferable for removing deep orbital tumors. If the tumor is not apparent and its site not discernible, the operation required may be termed an exploratory extra-aponeurotic external orbitotomy. The different stages are as follows: (1) Suture of the lids with silk, which preserves the cul-de-sac, facilitates deep examination and prevents corneal ulcer; (2) curved external incision at least 3 cm. long, starting from the end of the eyebrow, and going to the bone. The anterior structure is then divided close to the orbital border; (3) digital exploration of the orbit, with avoidance of injury to the enclosed fat, muscles, vessels and nerves; (4) removal of the tumor and suture. A space is thus entered which contains no important vessels, muscles or other structure, and in which tumors commonly develop. This marginal route can be followed quite far externally.

External orbitotomy combined with an orbital wall resection is occasionally indicated. The author's experience with the Kroenlein technique for temporal resection of the external orbital wall has been wholly satisfactory. General anesthesia is necessary. The eyebrow should be shaven, as well as the hair, from the temporal region. Several different skin incisions may be made to approach the orbital wall. The original Kroenlein incision was curved with the convexity forward, 7 to 8 cm. in length, beginning 1 cm. above the angular process at the frontal bone and ending at the middle of the zygoma. Terrien's incision is that of a Y lying upon its side, the two short arms over the orbital margin, the long arm continued posteriorly and horizontally to the midline of the zygoma. See Figure 77 A, for the site

[1] Lyon chir., 19, 760, December, 1923.

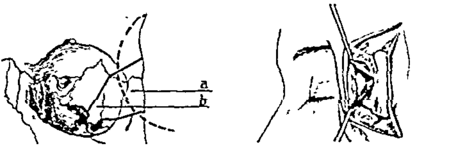
of the skin incision. It is carried through the skin, the fascia, and the muscle, down to the bone; the periosteum along the margin of the orbit is then incised and the peri-orbita of the lateral wall of the orbit elevated posteriorly to the spheno-maxillary fissure. This can be done with a blunt dissector. The contents of the orbit are then retracted medially and a wedge-shaped piece of bone cut from the outer wall of the orbit. See Figure 77, *B*. According to Terrien, the limits of the bone resection are from just above the frontal malar suture line, to a line made above the zygomatic



A *B*

Fig 77.—*A*. skin incision for the Kroenlein operation *B* the resection of the orbital wall

process of the malar posteriorly; it extends into the orbit in a converging line to the spheno-maxillary fissure. It cuts obliquely downward across the great wing of the sphenoid. It is quite possible to cut this wedge with a chisel and mallet but the bone may be splintered because of this The author prefers to start the orbital wall resection with a Gigli saw To use this, a drill (with brace and bit), is placed behind the rim of the orbit superior to the frontal-malar suture line, the direction of the drill being backward, downward, and slightly inward As soon as the point of



A *B*

Fig. 78 —*A* sketch to illustrate the wedge of bone *B* exposure possible through the orbitotomy

the drill appears in the orbit it is removed, a saw is threaded through the hole, and the heavy external boss of the orbital margin cut cleanly with this. Figure 77 *B*, illustrates the position of a Gigli saw in making this resection. The same procedure is carried out below, posterior to the orbital rim, so that the lower angle of the orbital margin is cut in the same way. A delicate but sharp chisel, with mallet, is then utilized for completing the resection. The periosteum may be reflected from the anterior external rim of the orbit externally as far back as the position of these

drill holes. The point of the chisel must be directed from within the orbit, to prevent damage to the contents of the orbit itself. As this wedge of bone is cut with the chisel, the periosteum on the external surface of the orbit must be cut as well as the bone. The soft tissues which lie within this fossa posterior to the external rim of the orbit should not be disturbed more than is absolutely necessary so as not to endanger the viability of the hinged bone flap. Figure 78, *A* and *B*, illustrates the bone included within the wedge outlined, and *b*, the exposure made possible by the movable wedge *a*. (Before the optic nerve itself can be seen, Tenon's capsule must be opened horizontally exposing the nerve and the cone of muscles.) After the wedge, *a*, has been loosened and is folded back, the wedge remains hinged to the orbit by this adherent periosteum. The peri-orbita which had been lifted prior to the orbitotomy, is incised, in a horizontal direction, with a blunt scissors, retracted, and the orbital contents are in full view of the operator. Adequate hæmostasis is necessary for this operation; in fact it is wise to use suction sponging similar to that used by the rhinologist in tonsil surgery, using a ball-pointed delicate tip instead of the large tonsillectomy suction tip After exploration of the orbit, and the identification of a tumor mass, the muscles may be moved about with blunt hooks as necessary and retracted with temporary black silk sutures. If adequate exposure is not possible, the external rectus may be severed, and No. 3-0 plain catgut whip-stitched through the two ends so that these can be readily joined later. In removing a tumor mass from the orbit, blunt resection should be used alone. The blunt end of the common double-ended periosteal elevator is ideal for this. One must be especially careful at the pedicle of the tumor so that vital orbital tissues are not removed with the tumor. The author has seen the optic nerve firmly adherent to a tumor mass, and in such instances, damage can occur if one is not quite particular. This same applies to the removal of cysts of the orbit; that portion of the cyst wall adherent to the optic nerve should be permitted to remain, in the orbit, deliberately, rather than to jeopardize the optic nerve by a forcible removal of this portion of the cyst wall from the nerve sheath.

As soon as the orbital surgery has been completed, attention is again paid to complete hæmostasis; the bone flap is then turned inward and forward to fit accurately at its former position. The periosteum of the wedge of bone is then sutured to the periosteum of the contiguous orbit with No. 1 plain catgut sutures, and the periosteum and peri-orbita joined over the rim of the orbit with interrupted sutures of the same material. Occasionally before the skin is closed a small drain is placed in the orbit to remain for a day or two. The skin should be done in two layers, No. 3-0 plain catgut for the fascia and muscle, and interrupted dermal sutures for the skin. The lid margins are then mattressed together with a black silk suture, through the two lid margins, and this tied. The dressing placed over this is firmly bandaged, and the gauze bandage reinforced with a wetted starch bandage over it. The opposite eye should be closed with a light compress dressing for the first four days. If no intercurrent complications or symptoms develop and if no drain was inserted, the first dressing may be done upon the seventh day. If a drain was placed in the orbit, this ought to be removed no later than forty-eight hours after the operation; the wound then re-dressed as above.

Bruck[1] also is satisfied with the applicability of the Kroenlein operation for the removal of cysticercus of the posterior half of the eye. Martin Cohen has used the Kroenlein operation successfully in several instances for chronic inflammatory exophthalmos without suppuration. In his opinion the operation is indicated to relieve the marked orbital pressure caused by the inflamed retro-orbital tissues. The operation in this way corresponds to the procedure of trephining the skull for increased intracranial pressure due to tumors of the brain, or to scleral trephining in cases of intra-ocular pressure due to glaucoma.

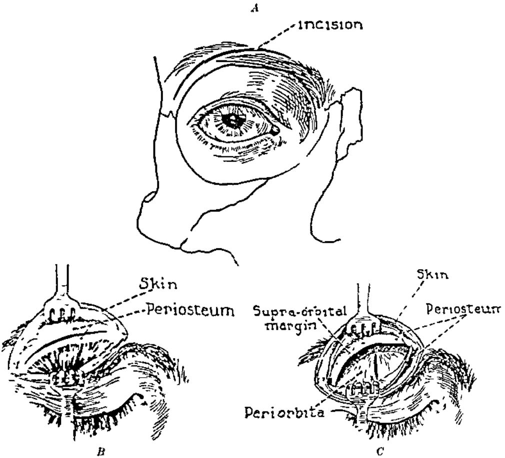


FIG. 79.—*A*, skin incision; *B*, retraction of soft tissues and periosteal incision, *C*, orbital exposure and radial incision of the peri-orbita. (Benedict, personal communication, and Surgery, Gynecology and Obstetrics)

Benedict uses a trans-conjunctival route for the removal of an orbital tumor in all cases except where the tumor is probably located in the outer portion of the orbit. An incision is made over the right temporal region starting above and to the temporal side of the brow, turning to the external outer rim at the outer canthus, thence down and out. The periosteum is incised near the temporal margin and the peri-orbita elevated with a periosteal elevator to the apex of the orbit. Digital palpation is then made through the peri-orbita for identification of tumor masses. The peri-orbita

[1] Arch. Ophth , **13**, 1043, June, 1935.

is then to be incised radially above the external rectus muscle and the muscle moved downward and out of the way, and not divided. After the tumor resection the peri-orbita is closed with catgut and the skin sutured for primary healing. The technique has been quite successful in his hand for the removal of orbital glioma. See Figure 79, *A*, *B* and *C*, from his original text, to illustrate his orbital approach and the radial incision of the peri-orbita at that place most suitable for removal of the underlying tumor.

When the tumor mass lies to the medial side of the orbit, Lagrange, in addition to the orbitotomy, incises the conjunctiva from twelve to six o'clock over the internal rectus 10 mm. from the limbus. Thereafter the eyeball and the orbital contents are pushed to the extreme temporal portion of the orbit permitting considerable space for exploration and for surgery within the orbit medially to the optic nerve. Figure 80[1] illustrates this.

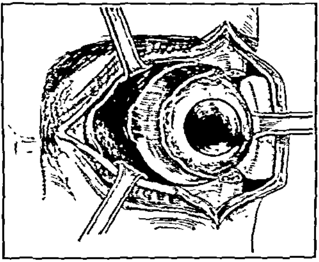


FIG 80 —The Lagrange orbitotomy for exploration at the inner angle of the orbit. (Modified after Terrien)

Algernon Reese[2] states· "It seems to the author that if a tumor cannot be removed from the depths of the orbit without sacrificing the optic nerve the wisest procedure is to immediately cease the routine procedure of the orbital exploration, and to proceed with a simple enucleation. If the nerve is so incarcerated with tumor mass that it must be sacrificed, there is a strong probability that the tumor is too extensive for its complete extirpation Non-malignant neurofibromata can be removed occasionally from the nerve with but little damage to the nerve. Sarcomata, however, and carcinomata, which would embrace the nerve, should have an enucleation done "

Reese prefers a trans-conjunctival route, either nasally or temporally, depending upon the position of the tumor in its relationship to the muscle cone. A canthotomy is performed and the fibers of the external canthal ligament, together with the tarso-orbital fascia are divided. (Fig. 81.) The conjunctiva is incised along the fornix to the vertical meridian above and below the canthotomy and dissected free. If the tumor is in the muscle funnel, the external rectus muscle must be severed at its insertion. By retracting the globe nasally, very good access to the orbit is obtained.

1 Terrien, Chirurgie De L'Œil, Masson et Cie, Paris, 1921.
2 Trans. Am Acad. Ophthal. and Otolaryngol., 1934

The temporal trans-conjunctival approach gives sufficient access to the orbit for the removal of tumors located anywhere but nasally. If the tumor is definitely in the nasal side of the orbit, the same trans-conjunctival approach can be utilized nasally. Even when tumors lie in the muscle funnel, and particularly in the apex of the orbit, and can be satisfactorily approached and removed, they sometimes are so adherent to the extra-ocular muscles that the muscles must be damaged in removing them. When such damage to the extra-ocular muscles is extensive, there will result an exophthalmos, a poorly aligned eye, and ptosis. When one or several extra-ocular muscles are damaged, it is sometimes advisable to fix the eye in the primary position so that the repair tissue formed later in the orbit around the globe will fix it in good alignment and with no proptosis. This can be accomplished by passing a silk suture through the lid margins and through the episclera at the limbus nasally and temporally, and tying over the surface of the lids. Figure 81 illustrates his trans-conjunctival approach as well as the sutures which he uses for fixing the eye in the primary position.

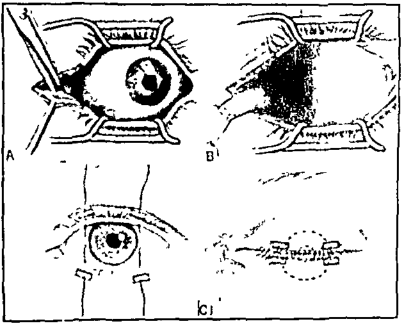


FIG. 81.—A, the conjunctival and skin incision; B, the exposure possible after resection of the external rectus; C, fixation of the eyeball to the lids (Reese.)

It is relevant here to mention again Naffziger's decompression of the orbit by resecting the orbital roof. While his opinion was based upon the treatment of malignant progressive exophthalmos as seen in hyperthyroidism, Adson, Grant, and Dandy have all demonstrated its value in orbital explorations. Naffziger states:[1]

Just what relationship progressive exophthalmos has to disease of the thyroid is not clear, though unquestionably it is intimate; nor is the factor which causes the exophthalmos understood. Progressive exophthalmos usually has appeared in patients who have had partial thyroidectomy for exophthalmic goiter and is

[1] Arch Ophth., vol 15, March, 1936.

ordinarily associated with a normal or lowered basal metabolic rate.[1] It may begin, however, before the first evidences of thyroid disease appear and progress during the development of hyperthyroidism. In the event of thyroidectomy with subsequent hypothyroidism, it may progress still further. One sees exophthalmos of marked degree in relation to pituitary disease, especially eosinophilic adenoma. The microscopic picture of the orbital muscles in myasthenia gravis and in progressive exophthalmos associated with thyroid disease cannot be differentiated—it is identical. Lymphorrhages in skeletal muscles occur in thyroid disease also. The pituitary and thymus glands may be involved. In the cases observed by my (Naffziger) associates and me we have taken one or more sections from ocular muscles. Of about 30 specimens examined, all showed various stages of this process. Some of the patients had evidence of chronic changes in their sinuses; two of them had been operated on. The microscopic picture in their muscles was identical with that described above, and with that in the case of thyroid disease not associated with changes in the sinuses. While many of the clinical relationships of progressive exophthalmos are apparent, there is not sufficient evidence to permit one to do more than speculate on the etiologic factor involved. In persons who have progressive exophthalmos resulting from an enlargement of the orbital muscles, the fundamental factors are not altered by moderately increasing the space in the orbit, either by decompressive removal of its roof or by a Kroenlein procedure. Decompression must be extensive. Removal of the entire roof of the orbit is often inadequate. We have added removal of the lateral wall of the orbit and of the bone down to the orbital fissure. I (Naffziger) believe that orbital decompression should be performed on any patient with marked exophthalmos. In many patients the progress of the exophthalmos will halt spontaneously before serious complications occur. Orbital decompression of any type is not recommended, for cosmetic reasons.

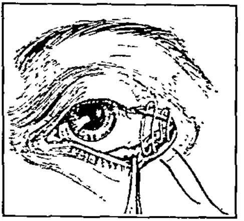


FIG. 82.—Wheeler's tarsorrhaphy for palpebral fissure shortening. (Reese)

Graves[2] in discussing the surgical handling of thyroid exophthalmos states that in spite of medicinal and surgical treatment in the ordinary run of cases of exophthalmos, proptosis with enlargement of the palpebral fissure and inadequate protection of the eyeball may persist.

Shortening of the palpebral fissure alone is worth something to these patients, but in most cases Wheeler has done a combined operation of fissure shortening and reattachment of the external canthal ligament. (See Fig. 82.) By dissecting up the external canthal ligament and making exposure of the periosteum of the malar bone and re-anchoring the external canthal ligament in a position behind the orbital margin, the lid margins are put on the stretch and the fissure is narrowed. But as narrowing of the fissure is not enough, it should also be shortened. Briefly, a groove is prepared in the outer part of one eyelid and a tongue of denuded tissue is prepared in the corresponding part of the other eyelid. With the epithelium removed from the contact areas of both lids, it is possible to get accurate union of as many mm. as desired and to have, as a result of the combined operation, both a shortening and a narrowing of the enlarged palpebral fissure, and it is possible to have an outer canthus that has a normal appearance with a permanently acute angle.

[1] See statement made by Rudemann relative to this, pages 38–39

[2] Am. Jour. Ophth., Series 3, vol. 17, August, 1934.

Hildreth[1] also speaks of the mobility which one can obtain in surgery of the lower lid and of the palpebral fissure following an external canthal ligament tenotomy. The deformity resulting, as Hildreth states, amounts to a decrease in the total size of the palpebral fissure, and is made at the expense of the horizontal dimension. It is much less noticeable than a variation of the vertical measurement. Slight amounts of lagophthalmos, exophthalmos, and ptosis are very apparent, but the horizontal length of the fissure affects the general appearance but little.

Dermoid cysts, fibromata and neurofibromata of the orbit, and lipomata can be removed without complications. An osteoma, especially that type deep in the orbit, seen in Figure 35, needs considerably more bone work. It may be wise to use crushing forceps in such instances and remove the tumor mass in this way. Myxomata, chondromata, psammomata, adenomyomata, plasmomata occur in the orbit by extension from the mouth or from the nasal accessory sinuses. The surgery of these cases the author feels should be done by the operating rhinologist. Meningiomata occur in the orbit by an extension of the tumor from the cranial cavity. Orbital exenteration is then necessary in these cases when operable, and this must be combined with the craniotomy by the neuro-surgeon. A lymphangioma or hemangioma should not be removed surgically before sufficient roentgenray treatment has been used to cause extensive fibrosis. The myxotumors, sarcomata, and carcinomata and the orbital glial tissue tumors must be followed, after resection, by radium implantation. It is remarkable how readily these tumors, even those with a high degree of malignancy, can be removed when encapsulated. If they are not encapsulated, exenteration must be done forthwith.

ORBITAL EXENTERATION

Enucleation of the eyeball and the various procedures for this purpose are considered under operations upon the globe. An exenteration of the orbit, however, is considered at this point. Cross reference will be made to this in the section on surgery of the globe so that no confusion should occur. In some instances an orbital evisceration need not be wholly complete, that is, the conjunctival surface of the upper and the lower lid can be occasionally spared and the cosmetic surgery, if it is to be done several years later, is a simpler process. In cases wherein the conjunctival surface of the upper and lower lid must be removed, the subsequent corrective plastic surgery is more difficult. Other cases present themselves wherein the major portion of the skin surface of the lids as well had to be sacrificed. Each case is individual. It is most desirable, however, to spare as much tissue as possible, without jeopardizing the results for which this disfiguring though necessary operation is designed. The original incision is to be made through the skin of the lid, through the lid margin, or deep into the upper and lower cul-de-sacs, depending upon that which has just been discussed. The periosteum on the orbital rim is then incised and the entire peri-orbita loosened to the orbital apex; the attachments at the L-shaped sphenoidal and maxillary fissures must be incised with small, sharp, curved scissors. As soon as the orbital contents are mobilized as a movable ball, the entire mass is resected at the apex with stout enucleation scissors. The remaining

[1] Am. Jour. Ophth, Series 3, vol 18, May, 1935

portion of the periosteum and the tissue in the depths of the orbit should be cleaned out with meticulous detail. The bony wall of the orbit should be carefully inspected to satisfy oneself that there is no disease of the bone demanding resection. If the conjunctiva has been spared, the upper and the lower fornices are stretched out by dissection and this tissue pushed into the depths of the orbit and held in place by packing. If this tissue is not available, the lids as two fleshy folds with their denuded posterior surface are pushed into the orbit covering as much of the bared bone, with this tissue, as is possible. The remaining bared bone may be grafted immediately with a Thiersch graft, this also being held in place by the packing. The success in such grafting has been only fair. It is permissible to allow this space to granulate over if one thinks it wiser. If the lid margins can be spared, the lashes should be trimmed very short, but the lid folds are forced into the orbit. Benedict feels that the lid margins and the tarsal plates should not be spared in this original dissection and immediate repair; also, if the peri-orbita does not share in the malignant process, that this must be conserved. If the lid margins and the tarsal plates can be permitted to remain, later subsequent correction of the total symblepharon present will be made a much simpler procedure. Various operators have used a tongue-shaped pedicle flap from the forehead into the orbit in the interspace between the two lid margins with good results. Naturally this should be done at the time of the exenteration. If the patient recovers and is of such an age that the cosmetic blemish is to be corrected, it seems more logical to do the cosmetic plastic surgery at a later date, and to do no more at the time of the exenteration than that which is essential.

The practice of packing an exenterated orbit posterior to the lids is to be condemned. Healing is not stimulated, recovery is delayed, and the subsequent removal of this packing gives great pain to the patient. It is an established surgical rule that bared bone must be covered with soft tissue and with skin.

A razor cut graft may be used. It should be wrapped over a tampon-like mass of petrolatum soaked gauze. This is fitted to the exenterated orbit, then removed, the graft placed over the tampon and graft and tampon forced into the orbit and a pressure dressing applied. The first dressing should not be done before the seventh postoperative day.

The numbness of the forehead and of the face which follows so frequently after orbital evisceration calls attention to the damage to the supra- and the infra-orbital nerves which results too frequently from this surgery. Care should be taken to preserve the exits of these nerves whenever it is possible.

CHAPTER III

SURGERY OF THE LACRIMAL APPARATUS. LACRIMAL GLAND SURGERY. EPIPHORA. ACUTE AND CHRONIC DACRYOCYSTITIS. DACRYOCYSTECTOMY AND DACRYOCYSTORHINOSTOMY

SURGICAL CONDITIONS OF THE LACRIMAL APPARATUS

It is occasionally necessary to remove the lacrimal gland because of malignancy. Either sarcoma or cylindroma may appear in the gland.

The incision for this passes through the upper lid immediately beneath the rim of the orbit, from the mid-line of the upper rim down to the level of the external canthal angle. The dissection is carried down to the orbital rim periosteum, but all subsequent surgery is extraperiosteal. The gland can be reached by retracting the orbital contents down and in. In such instances it is advisable that the lesser lobes of the lacrimal gland, as they lie in the upper lid, be carefully examined, and if at all suspicious, they should be extirpated. This can be done through the same incision. The palpebral portion of the lacrimal gland lies beneath the aponeurosis of the levator toward the latter portion of the upper lid in close contact to the palpebral conjunctiva, in fact adherent to it, for its ducts pass through the conjunctiva into the fornix. Whitnall calls attention to the fact that it is not uncommon to find lobules of this portion of the gland extending downward to the lateral raphé of the orbicularis and to the lateral palepbral ligament. It is necessary to cut through the aponeurosis of the levator palpebræ superioris, in its lateral horn, to reach the gland for extirpation, and one should have no difficulty in finding and identifying the accessory lobe and lobules. After extirpation, the aponeurosis of the levator should be carefully sutured with No. 3-0 plain catgut sutures This can be simplified greatly if two rows of catgut sutures are placed in the aponeurosis before it is incised, parallel to the orbital margin, and the incision carried out between them; the edges of the muscle will not be lost, and closure of the aponeurosis will be achieved by tying these four ends together. Davis[1] presented 2 cases of neoplasms of the lacrimal gland. He stated that the surgical approach may be by means of an incision through the upper lid along the upper lateral orbital margin as has just been mentioned, or by means of the Kroenlein incision. In these cases one should not be hesitant about the postoperative use of radiation to destroy any portion of the tumor which may remain. This is especially true in cases in which the neoplasm is either not definitely encapsulated, or with cases in which the neoplasm shows signs of infiltrating the surrounding tissue or bone.

In Mikulicz's disease, a histological similarity between the lacrimal and the salivary glands undoubtedly accounts for their simultaneous or successive involvement. Berens confirmed this in the histological studies of a cylindroma. Brown combined extirpation with large doses of radium. As the condition may disappear without surgical treatment, gland extirpation is to be done only after serious consideration.

[1] Arch. Ophth., vol. 12, July, 1934.

Resection of the lacrimal gland or the accessory lobe of the lacrimal gland has been done several times for the correction of epiphora following dacryocystectomy. In such instances it is simply the substitution of a dry eye for a wet eye, and the former of the two evils is by far the worse. It is doubtful whether the procedure should ever be carried out for this condition.

Surgery of the gland itself should be done under general anesthesia. If the accessory lobes of the lacrimal gland alone are to be removed, this can be done through an incision deep in the superior cul-de-sac just above the superior border of the tarsus. An incision 10 to 15 mm. long is made, the conjunctiva freed and retracted, and the gland can be easily recognized by its pale lobulated appearance. The arterial supply to the gland enters at its temporal margin; therefore, one should dissect from the inner margin temporally. The surgery of the sac, however, whether it is a cystectomy or a cystorhinostomy, can be done readily under local anesthesia.

SURGERY OF THE LACRIMAL SAC

Simple epiphora is not always due to lacrimal sac pathology. Refractive errors, occupational diseases, chronic nasal pathology, and many other causes, all result in epiphora. Repeatedly pathogenic organisms are found in the sac without any signs or symptoms of acute or chronic irritation. The bacterial flora of the lacrimal sac differ but little if any from the bacterial flora of the nasal mucosa. It is astonishing to see the frequency with which polypi appear in the lacrimal sac as a result of chronic inflammation of the nasal mucosa. Epiphora of the new-born, with and without suppuration of the sac, is not uncommon, though most of these cases recover rather promptly following irrigation of the sac and penetration thereby of the imperforate inferior pole of the sac where it passes over into the lacrimal-nasal duct. Occasionally a No. 1 Bowman probe must be used to perforate this. Epiphora occurs with eversion of the punctum. It is more common in the aged. This can be corrected by several shallow Ziegler cautery punctures at the conjunctival base of the punctum.

The practice of slitting the canaliculus has fortunately become obsolete. In those instances where it has been slit, but only in cases with the lips still in opposition, a fair superior bridging of this tunnel can be obtained by repeated cauterization. This must start at the extreme inner angle of the canal and the lips and side of the trough lightly cauterized. Contraction occurs in a large percentage of the cases and with healing a new roof is formed to the canaliculus. Not more than 1 or 2 mm. should be cauterized at a time. The process is then repeated as often as is necessary. Each time before fresh cauterization is done, the canaliculus should be probed and dilated with a No. 1 probe to assure oneself that the patency of the duct has been maintained. Occasionally the punctum is lacerated following too vigorous probing and dilating. Superficial cauterization about the punctum will also correct this. In these treatments for the canaliculus and about the punctum, the finest wire needle should be used. Many such articles are on the market. Cicatricial contraction of the canaliculi should be dilated with a No. 1 or No. 2 probe and a silver wire then threaded through the canaliculus across the sac and into the lacrimal-nasal duct. No. 24 to 26 gauge silver wire is satisfactory for this. Before the wire is

passed the advancing end of it must be smoothly rounded with a light file. This must be worn for several months until irrigation through the canaliculus is always successful. Benjamin and van Romunde[1] recognized the importance of a slit canaliculus in continuing epiphora and state, further, that epiphora will not cease until this has been corrected. The author has used their operation repeatedly with complete success in each case. The technique given by the *International Medical and Surgical Survey* vol. 4, August, 1922, No. 2, p. 103 is as follows: A few drops of 5 per cent cocain solution are introduced into the conjunctival sac; a few minutes later a small quantity of a 1 per cent novocain-adrenalin solution is injected, by means of a fine needle, into the conjunctiva and the skin near the canaliculus. The canal is exposed, and the outer border of the cleft trimmed with fine scissors as far as the inner canthus. A small rectangular flap is then cut in the conjunctiva the same length as the cleft duct, and approximately 2.5 mm. wide, the duct forming the line of attachment of the flap. This flap is freed from the underlying tissues, care being employed not to tear the line of attachment and the flap, free on three sides, folded over the canal, and sutured to the trimmed outer border of the fissure. The sutures may be removed in four days. Care must be taken that the duct is closed at the inner canthus, or a fistula may appear. The technique is recommended in all cases of extensive splitting of the inferior duct in which disturbance of lacrimation persists.

Rather recently Jameson[2] recommended for an intractable epiphora a partial subconjunctival sectioning of the ductules of the lacrimal gland. His technique is as follows:

> An opening is made on the conjunctival surface of the lid adjacent to and slightly below the outer canthus. This must be large enough to admit Stevens scissors and to allow free manipulation. The upper lid is then everted so that the fornix is put on a stretch. The scissors are made to separate the conjunctiva from all the basic tissues of the fornix through the primary conjunctival incision for a distance of the outer two-thirds. The subconjunctival separation of the fornix from its basic tissue should extend in breadth 5 or 6 mm from the margin of the tarsal curve to the beginning of the bulbar conjunctiva, and in length this broad separation strip should measure some 15 to 18 mm The primary incision should be beneath the external commissure, as one of the largest ductules is situated below, and the subconjunctival dissection at the commissure should come farther forward to the margin of the lid in this region. The operator should have in mind the anatomical location and distribution of the openings. This is not difficult, as the points of the scissors can be seen for the most part through the transparent conjunctiva. The openings of the ductules are not evident, however. If the points of the scissors are invisible it is an indication that the operator has got a little too deeply into the conjunctival basic tissue. An accident which must also be avoided at this point is the sectioning of the levator muscle of the lid at its insertion into the tarsal cartilage. This cannot occur if the operator watches the points of the scissors and has in mind the anatomy of the parts. On completion of the conjunctival separation from the basic tissue of the fornix, the bulbar conjunctiva adjacent to the fornix is put on a stretch, and the field of separation is gone over again, the operator making sure that the division of the fornix and the conjunctiva from their basic tissues is complete. If this separation is complete every ductule has been sectioned. Sometimes when there is little bleeding, the accumulated watery secretion can be observed through the translucent conjunctival fornix The reaction is slight, and there is little hæmorrhage, although sometimes slight discoloration on the surface of the lid caused by moderate extravasation of blood may

[1] Nederl. Tijdschr v. Geneesk, Haarlem, 66, 33, 1922; Arch. f. Ophth, Berlin, 109, 221, October 2, 1922.
[2] Arch. Ophth., 17, 207, February, 1937.

exist. This, of course, disappears quickly. One can reason that the postoperative condition as far as the ductules are concerned predicates the final obliteration of their orifices at the fornix so that there is no lacrimal secretion passing from the duct proper to the sac. On the other hand, the openings at the end of the severed ductules may remain patulous for some time, and the accumulated and constantly flowing secretion of the gland is therefore evacuated into the tissues instead of into the conjunctival sac. One feature of the procedure is that to a certain extent it can be graded. Should one wish to leave some of the ductules intact, the length of the dissection can be limited to the desirable extent.

Fresh lacerations and incised wounds which cross and cut the canaliculi, if corrected immediately, will result in good function. It is wasted time to look for the cut end of the canaliculus, however, even by oblique illumination and magnification. A much simpler procedure is universally successful. The punctum is dilated and a No. 2 Bowman silver probe passed through the punctum and into the canaliculus so that about 0.5 cm. of the probe projects beyond the cut or lacerated lip of the wound. Using this probe as a handle the cut edges of the canaliculus are fitted together anatomically and accurately with careful and delicate manipulation. The projecting tip of the probe should slip into the proximal or fixed cut end of the canaliculus and through this into the sac. While the probe is held in this position, at least three sutures are to be placed bridging the laceration; one upon the posterior surface of the lid as near to the lid margin as is convenient; a second upon the anterior surface of the lid matching the first in the conjunctiva; and a third, double-armed fine black silk suture, mattressed through-and-through the lid surface, placed from the conjunctival surface outward, the loop crossing the laceration a short distance below the lid margin. Before these are tied the probe is passed through the sac into the lacrimal-nasal duct. As the probe is fixed in the duct it is bent out upon itself so that the right angle bend lies in the sac proper. That portion of the probe which extends beyond the punctum is cut, with a wire cutter, and the end of it bent upon itself again, downward, so that it will lie below the level of the lid margin. In this way the probe can be retained in place, horizontally without convexity or concavity, the canaliculus will not be torn as a result of the retention of this probe, and the probe itself is not so large that it will result in necrosis of the canaliculus. The three sutures are now tied, the mattress suture first and then the conjunctiva and skin sutures. The skin, orbicularis, and conjunctiva are closed in layers according to directions outlined in section on Lid Repairs. See Figure 83. The eye is to be dressed with a plain dressing for six days. Daily removal of the dressing should be done accompanied by irrigation of the cul-de-sac. The probe and the sutures may be removed upon the sixth day. Care must be taken in removing the probe that it be taken out with a smooth external swinging motion otherwise the original wound will be reopened. Dilation of the cicatricial stricture may be necessary for several weeks at weekly intervals. The procedure has been universally successful with the author. Older lacerations of the canaliculus with cicatricial contractions are treated in the same manner, except that the scar is first outlined and resected. This converts the defect into a fresh laceration. After the above procedure has been carried out, one may then continue with the other plastic surgery necessary and complete the case with adequate and properly placed sutures to prevent the later development of a lid margin notch near the inner angle. See Figure 84.

Cicatricial contraction of the lacrimal-nasal duct as a result of chronic irritation is not a simple problem. Ziegler's method of rapid dilation causes trauma to the mucous membrane and to the bone of the lacrimal duct. The

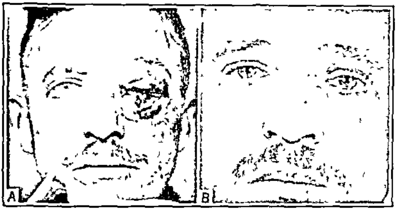


FIG. 83.—Fresh laceration of the lower lid at the inner angle, and condition repaired after suture of the lids in layers and with complete reëstablishment of lower canaliculus and of lower lacrimal drainage. (There is an interval of four weeks between the two photographs.)

secondary cicatrix resulting may be even worse than that which was originally present. In adults, rapid dilation of the lacrimal-nasal duct can be done with good results occasionally *following the recession of an acute* suppurative dacryocystitis. Dilation during an attack of suppurative

FIG. 84.—Two cases before and after surgery; scar resection with suture and anastomosis of the cut ends of the inferior lacrimal canaliculus

dacryocystitis is not wise. *An extensive cellulitis may occur* as a result of this. Fuchs states that a permanent cure of any condition of the lacrimal sac through probing is a rare exception. The patency of *a portion of the*

lacrimal-nasal duct is readily maintained by irrigation. The punctum should first be slightly dilated, and then the tip of the needle introduced vertically into the punctum, then directed horizontally along the canaliculus until it is within the lacrimal sac. The contents of the syringe should be expelled slowly. In dilating the canaliculus, preliminary to irrigation, the dilator used is passed in the same way. If too large a dilator is used the mucous membrane of the duct, and even the duct itself, will be ruptured. Care should be taken that false passages are not formed by too sharp or too small a probe. This error occurs most commonly in forcing the probe through the wall of the lacrimal sac, then the probe follows the bone outside of the wall of the lacrimal-nasal duct at its lateral side. Presence of hæmorrhage while probing a canaliculus is always to be viewed with concern.

Brown[1] has recommended the use of a sea tangle probe for dilation of a stricture of the lacrimal-nasal duct. (The author has repeatedly used it with satisfaction.) The sea weed from which they are made, is dried and trimmed to standard lengths. Contact with water causes it to swell to at least twice its size. (When one of these probes is removed, upon its circumference can be seen the constriction rings of the internal punctum, the junction of the lacrimal sac and the lacrimal-nasal duct, and the position of the stricture itself.) After preliminary dilation of the punctum of the canaliculus, the probe is passed through the lacrimal sac and into the lacrimal duct with the same technique that one would use with a Bowman probe. The operator should stand behind the patient with the sea weed grasped with a fixation forceps near its tip as it is threaded through the canaliculus. As soon as the probe is in the sac, it is elevated to a vertical position and then directed downward across the sac slightly posteriorly and with a slight internal inclination into the duct. Cocainization of the cul-de-sac should precede this procedure and it is well, also, to inject a few drops of a 4 per cent cocain solution into the sac. The sea tangle probe cannot be forced into the lacrimal-nasal duct; it is dry, at the start, and may break. After the probe is well in the lacrimal-nasal duct, the patient is told to close his eyes and to be quiet for fifteen to thirty minutes. The probe is then withdrawn, with forceps, in the reverse order to that by which it was introduced It is now soft and swollen and will not break as readily. Its withdrawal should be done slowly, however, to prevent pain.

Probing with a metal probe is carried out rather similarly, whether with local or general anesthesia. The punctum and canaliculus are first dilated, the probe is then passed vertically into the punctum and immediately depressed to a horizontal position for its passage through the canaliculus. As soon as it is in the sac, the probe should be raised to a vertical position for passage through the sac. If it is correctly placed, the skin of the lower lid will become taut without folds; the lacrimal sac and the mouth of the bony lacrimal duct are acting upon the probe as a fulcrum. The patient has been looking up during this procedure. As soon as the vertical position of the probe is reached, the patient may close his eyes and the probe be directed gently downward, the tip in contact with the inner wall of the lacrimal sac as it lies against its bony fossa. This contact is continued while passing the probe through the lacrimal-nasal duct. The rugæ within the duct will be smoothed out, with minimum trauma, if the probe is slightly withdrawn whenever resistance is met and then subsequently

[1] Arch. Ophth., 57, No 4, 1928.

A

B

FIG. 85.—Lipiodol injections to show obstructed lacrimal-nasal ducts.

advanced. No probe of any kind should ever be introduced for a greater distance than the level of the nasal opening of the lacrimal-nasal duct. These procedures have been described as applying to the inferior punctum and the inferior canaliculus. Similar procedures can be carried out with the superior punctum and canaliculus if necessary.

The certain diagnosis of an obstruction of the lacrimal-nasal duct should be confirmed whenever possible by the injection of warm lipiodol through the inferior punctum into the lacrimal sac, and immediately thereafter, a roentgenogram is to be taken to determine whether the lacrimal-nasal duct is patent. This should always be done prior to any surgery for obstructive dacryocystitis; also before radical dilation is attempted of the lacrimal-nasal duct itself. Figure 85 is a roentgenogram of an obstructed lacrimal-nasal duct showing the lipiodal only in the sac, *A*; and free, *B*, in the conjunctival upper and lower cul-de-sacs at the inner angle.

Acute suppurative dacryocystitis must be incised, frequently, to allow for drainage. If the standard accepted procedures for the treatment of cellulitis are of no avail, rupture of the sac may occur. The fistula which results from this will be permanent unless and until further surgical work is carried out. A clean surgical incision of a suppurative sac may also result in a fistula, but the site for the incision can be selected; and following the incision and drainage, lacrimal probing and packing with one or more strands of chromicized catgut through the lacrimal-nasal duct will, in many instances, re-establish patency of the duct. Even probing with a small Ziegler dilator, through this incision, is successful in a great number of cases. Harsh procedures, however, will stir up further inflammation and nullify any beneficial results which might have occurred.

Ziaja[1] has recommended strongly the use of Gebb's method in the treatment of acute and subacute inflammation of the lacrimal sac. He uses 1 to 5000 mercury oxy-cyanate salve in all but pneumococcus suppurations and in this he uses an optochin salve. This is heated in a syringe and then injected under slight pressure until the lacrimal sac is filled and this filling can be both seen and felt. An ordinary Record syringe with a blunt cannula may be used. Ziaja has treated more than 200 cases by this method and his results, he insists, are uniformly good.

Extirpation of the lacrimal sac for a chronic empyema of the sac with occlusion of the lacrimal-nasal duct is occasionally indicated. The author feels that dacryocystorhinostomy is preferable, in the greatest number of cases, to dacryocystectomy. The latter is still indicated in serious ulcerated conditions of the cornea complicating a dacryocystitis and certainly with a tuberculous dacryocystitis. With these exceptions, however, the cystorhinostomy offers a much better operative treatment. A dacryocystitis, present in a case where intra-ocular surgery must be carried out later can be handled just as readily with a rhinosotomy, and the patient spared the resulting epiphora. (See Recapitulation, at end of this chapter.)

The lacrimal sac is frequently pictured, in drawings and in sketches, as a dilated or enlarged sacculation of the lacrimal-nasal duct. Actually, the lacrimal sac is the contracted superior extremity of the membranous lacrimal-nasal duct. This membranous and bony lacrimal-nasal duct may be divided into three portions; the superior contracted portion, wholly membranous and including about 12 mm. of the total length; a second

[1] Ztschr. f. Augenh., Berlin, 51, 39, August, 1923.

interosseous portion, which is the widest portion and includes 15 mm. to 16 mm. of the total length; and a third meatal portion which is buried in the mucous membrane of the lateral wall of the inferior meatus of the nose, taking up 4 mm. to 6 mm. of the length, and depending upon a multitude of normal variations in its inferior ostium. Whitnall has corrected these errors more than any other anatomist. The inferior meatal opening of the duct is also interesting. Aubaret examined 139 specimens. The inferior meatus was probably open in 80 of these, in the other 59 it was as apparently closed. He concluded, however, that regardless of the shape, the size, the dimensions, or the amount of inferior meatal opening, the normal ostium is always open to the air in the nose; and if any valves are present they are ineffectual, *i. e.*, of no importance. These can play no part in controlling, in any way whatsoever, the lacrimal drainage. Considerable importance has been attached, by some writers, to a valve-like action of the meatal opening. Whitnall noticed that the wide tubes had wide openings, as if tubes with wide openings were subject to a constant dilation and perhaps some atrophy through forcing air up into the ducts when blowing the nose. It seems to be impossible to attach any importance to this from a pathological standpoint, save the possibility of forcing infection into the lacrimal sac from the nose. When one stops to consider the high incidence of nasal and nasal accessory sinus diseases, it seems remarkable that more lacrimal sac pathology does not develop. It is likely that these wide tubes are not the result of any mechanical factors, nor are they pathological in themselves, simply one of the many varieties which appear, and further, that these are the ducts in which pathology does develop within the lacrimal sacs as a complication of, or a sequela of, an intercurrent suppurative, acute or chronic, nasal infection. No one type of inferior meatus can be considered ideal. Swerschewsky described three positions for this inferior meatal opening: the first, in the roof of the inferior meatus; a second, in the side wall of the inferior meatus; and a third, as a small canal in the front of the inferior meatus. The first group included 45 per cent of instances, the second group 49 per cent, and the third group included the very small remainder. The first and second groups showed some with folds (27 per cent), some with a diaphragm (25 per cent), some with a wide opening (18 per cent), some half open (16 per cent), and some with a small groove (15 per cent). Holmes measured 50 cases and found but slight differences from these figures. The same qualification applies to the various valves described. At the best they are inconstant. Most of them, while dignified by names, are simply folds or rugæ in the nasal mucosa. Of them all, the one most commonly present is the plica lacrimalis, or the valve of Hasner, lying at the meatal end of the nasal duct.

For the past nineteen years various methods have been considered which would correct the localized area of infection in the sac and at the same time cure permanently the epiphora. Both the rhinologist and the oculist have worked upon this problem, for not only was dacryocystitis to be considered but also dacryostenosis of the bony and membranous lacrimal-nasal duct. The only one point agreed upon by most men was that the old operation for the extirpation of the lacrimal sac did not cure the epiphora. In 1921, Gilbert studied 45 cases of cystectomy which had extended over a period of five years, from the rhinological service of the Massachusetts' Eye and Ear Infirmary. In this series of cases not one was free from

epiphora one and a half years after the operation, and, in about 50 per cent of them, this persisted from two to five years. In many cases the epiphora was severe and was made worse by wind or cold, and by the prolonged use of the eyes. In most instances the patients denied relief from the lacrimation and were willing to undergo further surgery if relief could be offered. It is no wonder that Dr. Mosher said, "Ophthalmologists to the contrary, epiphora does persist after lacrimal cystectomy." In speaking of cystorhinostomy, Knutson,[1] says, in certain cases in which the function of the canaliculi can be expected to be checked or to have ceased, it gives a bad surgical result. In order to relieve the patient quickly and relatively painlessly from the acute inflammation in the immediate surroundings of the lacrimal sac and from fistulæ, external extirpation in such cases becomes the rational procedure.

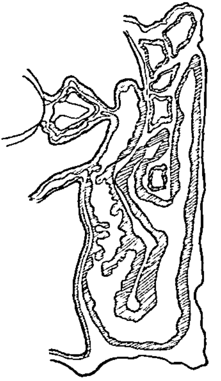


FIG. 86.—Schematic drawing of the anatomical relationship to the lacrimal sac

The various operations devised for an anastomosis of the sac with the nasal cavity are large in number. Some of them are purely endonasal operations, the others, and they are the greater in number, consist of a combined endonasal and external technique. Many of them are relatively difficult, others rather simple. They all have as their aim the re-establishment of lacrimal-nasal drainage for the tears. In 1904, Circione dissected the lacrimal-nasal duct and sac free from below up to the canaliculi. He then bored through the nasal wall into the superior meatus of the nose and tucked the sac through this opening. This was perhaps the first operation planned for the purpose which recently has become so much better understood. In the last few years many men have advanced a technique of their own for this purpose. Among them are West, Polyak, Toti, Dupuy-Dutemps and Bourguet working together, J. S. Clark, Andrew Campbell, Heyninx, Aubaret and Bremond working together, Halle, Kofler, Zarzycki and Mosher There are several others in addition, but their methods are invariably a modification of one already established.

West's operation,[2] which is purely endonasal, gave the originator 90 per cent recoveries in 480 cases. Other operators have reported from 80 to 90 per cent with this same type of operation. The technique is similar to that recommended by Halle and by Polyak. The method as given by Heyninx, through the American Institute of Medicine, is substantially as follows:

(1) Identification of the endonasal lacrimal region by means of a nasal

[1] Acta Oto-laryngol., 3, 126. Uppsala, 1921.

[2] West, J. W., The Clinical Results of the Intranasal Tear Sac Operation, Tr. Sect. Ophth. Am Med Assn., p. 69, 1931.

dressing forceps, one blade upon the skin over the lacrimal sac, the other extremity inside of the nose upon the nasal mucosa, thus determining the position of the lacrimal sac in its relationship to the nasal wall. (2) Anesthesia, general or by painting the whole of the region of the operation with 10 per cent cocain containing 1 to 10,000 epinephrin, with an injection of 5 per cent novocain-epinephrin into the nasal wall and into the skin over the nose and lacrimal sac region. (3) The anterior end of the middle turbinate may be resected. (4) A quadrilateral flap is outlined, with an inferior hinge, a posterior-superior point of this is above and behind the spot made by the dressing forceps. This flap is turned down exposing the internal face of the ascending process of the superior maxilla and the lacrimal bone. (5) With biting forceps, 0.5 cm. of the posterior-superior angle of this flap are removed, so that when it is replaced a window remains in the nasal mucosa at the level of the lacrimal sac. (6) Endonasal resection of a window in the ascending process and in the lacrimal bone with a mallet and chisel exposing a raw surface which is depressible with a probe. By digital pressure externally, the internal fibro-mucous wall of the sac is made to bulge into the nasal cavity. This bony window is then enlarged. (7) Endonasal resection of the internal wall of the lacrimal sac with a Hartmann punch. By digital pressure the sac can be made to bulge into the nasal cavity while this window is being punched out. (8) Replacement of the quadrilateral flap The mucous and bony windows must coincide. (9) Endonasal dressing of plain or iodoform gauze maintains this flap in position. West places most emphasis upon the removal of the bony lacrimal duct, while Halle attempts to save as much bone and mucosa as is possible. Undoubtedly, in suppuration of the lacrimal sac, West's operation should give permanent relief.

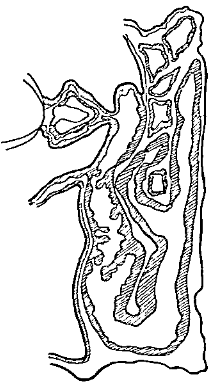
Clark's combined intranasal and extranasal operation eliminates an external incision, but a stab wound is made into the sac, and a Bowman probe passed through this into the sac. This, when pushed through the floor of the lacrimal fossa, locates the sac region and makes it possible to proceed from there to the endonasal window resection.

Of the combined lacrimal sac operations, there are four to be considered. Zarzycki incises the inferior canaliculus, raises the inferior portion of the sac, makes a T-cut in the inferior-internal wall of the sac, and then with a chisel or burr opens through the lacrimal bone into the nasal cavity, keeping the instrument against the middle of the superior orbital arch.

The techniques of Toti and of Dupuy-Dutemps and Bourguet have many points in common.[1] The procedure for the latter operation is as follows. Anesthesia is obtained with novocain externally, and with 10 per cent cocain with epinephrin pledgets applied intranasally. The external incision begins 0.5 cm. above the internal palpebral ligament, runs parallel to the lacrimal crest and downward slightly beyond the inferior border of the orbit, ending opposite the entrance of the lacrimal canal. The remaining steps are as follows: section of the internal palpebral ligament close to the bone; exposure of the lacrimal sac; resection of the lacrimal gutter, from a point on a level with the upper extremity of the sac down to or beyond the orifice of the nasal canal, including the internal portion of this orifice; longitudinal incision of the lacrimal sac and of the nasal mucosa;

[1] Dupuy-Dutemps and Bourguet, Pract. Med. Ser. Eye, Ear, Nose and Throat, Chicago, Year Book Publishers, pp. 98-101, 1928.

epiphora one and a half years after the operation, and, in about 50 per cent of them, this persisted from two to five years. In many cases the epiphora was severe and was made worse by wind or cold, and by the prolonged use of the eyes. In most instances the patients denied relief from the lacrimation and were willing to undergo further surgery if relief could be offered. It is no wonder that Dr. Mosher said, "Ophthalmologists to the contrary, epiphora does persist after lacrimal cystectomy." In speaking of cystorhinostomy, Knutson,[1] says, in certain cases in which the function of the canaliculi can be expected to be checked or to have ceased, it gives a bad surgical result. In order to relieve the patient quickly and relatively painlessly from the acute inflammation in the immediate surroundings of the lacrimal sac and from fistulæ, external extirpation in such cases becomes the rational procedure.



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The techniques of Toti and of Dupuy-Dutemps and Bourguet have many points in common.[1] The procedure for the latter operation is as follows. Anesthesia is obtained with novocain externally, and with 10 per cent cocain with epinephrin pledgets applied intranasally. The external incision begins 0.5 cm. above the internal palpebral ligament, runs parallel to the lacrimal crest and downward slightly beyond the inferior border of the orbit, ending opposite the entrance of the lacrimal canal. The remaining steps are as follows: section of the internal palpebral ligament close to the bone; exposure of the lacrimal sac; resection of the lacrimal gutter, from a point on a level with the upper extremity of the sac down to or beyond the orifice of the nasal canal, including the internal portion of this orifice; longitudinal incision of the lacrimal sac and of the nasal mucosa;

[1] Dupuy-Dutemps and Bourguet, Pract Med Ser. Eye, Ear, Nose and Throat, Chicago, Year Book Publishers, pp 98-101, 1928.

suture of the corresponding edges so as to form a communication at th point between the sac and the nose; and lastly suture of the skin.

Averbach and Ivanova[1] reviewed and classified all of the material at t Helmhotz Ophthalmic Hospital at Moscow for the last ten years. The ou standing point in their analysis of 1200 cases was that suppuration disap peared in 95.83 per cent of all instances, and epiphora disappeared in 90.9 per cent of all cases, and in some of these the epiphora was due to defec existing preoperatively in the canaliculi. The technique from the Helmhol Clinic for their plastic dacryocystorhinostomy was as follows. In childre general anesthesia was used, in adults, local anesthesia. A tampon o gauze saturated with 10 per cent cocain solution was inserted in the nose A curved incision was made over th tear sac down to the base. The peri osteum and internal canthal ligament and the tear sac were elevated, and the bone was laid bare in the region between the anterior and posterior lacrimal crests. With curved scissors the limits were marked out, and the bone was removed down to but not including the nasal mucosa. This gap was made as large as possible to avoid later diverticulum formation and to insure success of the operation. Its dimensions should be 15 to 20 mm. vertically and 10 to 15 mm. horizontally and should open below into the new lacrimal duct. The nasal mucous membrane was incised vertically to form two lips, an anterior and a posterior. The lacrimal sac was incised vertically through the periosteum which covered it. The posterior lips of each wound were united by three sutures, tied one after the other. The anterior lip of the nasal mucosa, the sac and the skin incision were closed by three sutures.

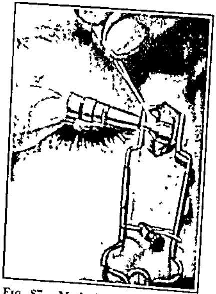


FIG 87.—Method of application for the osteotomy. (Arruga.)

Arruga,[2] utilizes a specially made trephine mounted in a chuck handle for preparing his osteotomy. After he has made his skin incision, the periosteum conserving the internal canthal ligament turned back, the trephine is applied as in Figure 87. The posterior sac wall is then resected, and the nasal mucosa incised. Arruga then sutures the posterior lip of the nasal mucosa to the posterior wall of that portion of the sac still intact, and subsequently the anterior lip of the nasal mucosa to the anterior edge of the sac.

CONGENITAL ABSENCE OF THE LACRIMAL SAC. AND RHINOSTOMY AFTER A PREVIOUS CYSTECTOMY

The internal canthal angle conjunctiva should be incised, anterior to the caruncle, and a small osteotomy made through into the nose with a dental burr. A No. 4 probe size piece of silver wire is then threaded through this,

[1] Ann. d'ocul., 172, 913, November, 1935.
[2] Conferences Ophthalmologiques, Lausanne Imprimeries Reunies S. A., 1937.

into the nose, its end therein bent downward under direct vision through a nasal speculum, and the external end cut and rolled into a loop to lie upon the surface of the lid. Six weeks later, this may be removed, and after two

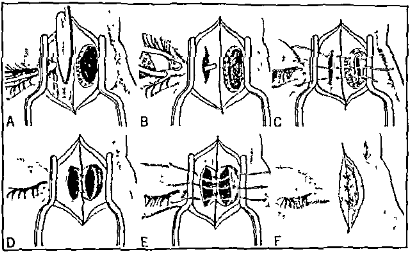


FIG. 88 —Illustrating direct anastomosis of the canaliculus and the nasal mucosa, *A* the osteotomy is completed and a probe lies in the canaliculus, tissue at the end of the probe is to be incised, *B*, vertical incision, *C*, and *D*, sutures from the posterior lip of the nasal mucosa *E*, and *F*, sutures from the anterior lip of vertical incision to the anterior lip of nasal mucosa (Arruga)

weeks again reintroduced for a second period for the same length of time A skin incision is then made over the side of this osteotomy, and a second piece of silver wire, of a No. 2 probe size threaded through the inferior canaliculus, and then through the osteotomy, its nasal end cut and bent upon itself to guarantee retention. The end which emerges from the

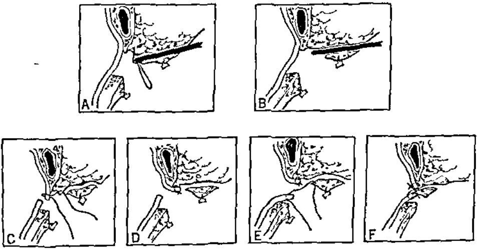


FIG. 89 —Schematic illustration of reconstruction of the canaliculi.

punctum is bent into a loop, this lying upon the skin surface. The silver wire must lie horizontally and without stretching the canaliculus into a superior convexity or concavity, for this would result in necrosis and

destruction of the canaliculus. The skin incision is then closed with sutures. The probe may be withdrawn, after its nasal end is straightened, and reintroduced at two weeks intervals during a period of six months. After this time a patent opening should continue in a very large percentage of cases.

Arruga's technique for absence of the lacrimal sac, regardless of the cause, is most clever. A rhinostomy incision is made, and the osteotomy performed with a trephine or with mallet and chisel, except that one must be quite careful not to damage the nasal mucosa. A stout probe is then passed through the inferior canaliculus until it pouts out the soft tissues within the skin incision, on the medial side of the depths of this. The tissues are there incised in a vertical slit (Fig. 88, *A*, *B*, *C*, *D*, *E*, and *F*). The nasal mucosa is then incised, also vertically, within the limits of the osteotomy, and the posterior lip of this sutured to the posterior lip of the first vertical incision, then subsequently the anterior lip of the nasal mucosa to the anterior lip of the first incision. As a result, the opened nasal extremity of the inferior canaliculus is buried into the nasal mucosa in such a manner that it cannot subsequently close. The skin incision is closed last. Postoperatively, one should start canaliculus irrigations on these cases on the sixth postoperative day, and continue them on alternate days until complete healing has occurred. Figure 89. *A* to *F* illustrates the technique schematically.

EXTERNAL CYSTORHINOSTOMY

One of the last operations to be described is perhaps the simplest of all. Its best example is the operation devised by Mosher, but inspired by Toti's operation.[1] In the hands of most of the American operators it has given quite satisfactory results. As Dr. Mosher states, "It is simple to execute and it is done entirely by sight." After he had had a number of successes with the endonasal operation, he abandoned it following one case in which the orbit became infected, though the eye was not lost. The technique as he gave it is about as follows. General anesthesia is preferred, though local may be given. If local anesthesia is done, nerve blocking as well as infiltration anesthesia should be used externally, and 10 per cent cocain with adrenalin applied with applicators–well wrung out, however, before they are introduced into the nose. The patient is placed in a semi-reclining position. The first step is the resection of the tip of the middle turbinate. The second is the exposure of the lacrimal sac. The incision lies 6 mm. from the inner canthus of the eye, starts on a level with the crease of the upper lid, runs downward in a nearly straight line, on the ascending process of the superior maxilla, parallel to the bed of the sac, and stops 3 mm. below the level of the bony orbit. The incision is made down to the periosteum. The sac is exposed and turned from its bed by entering the orbit above the sac and elevating the periosteum of the orbit from above downward. The periosteum of the inner wall of the orbit is elevated for 2 to 3 mm. beyond the crest of the lacrimal bone. The sac is freed and turned outwardly until the beginning of the nasal duct is clearly seen. The third step is the breaking down of the lacrimal bone in front of the crest. This is done with a knife, a small flat chisel, or the end of a punch. A sufficient opening is

[1] Presented at the Boston Meeting of American Medical Association, 1921. Further publication in Spaeth, Newer Methods of Ophthalmic Plastic Surgery, P. Blakiston's Son & Co., 1925.

made to allow the introduction of a Kerrison punch or some similar instrument. With this the rest of the lacrimal bone in front of the crest is bitten away, then the posterior edge of the ascending process where this makes the anterior half of the bed in which the sac rests. The bone opening should be at least equal to the height and the width of the sac. Then with a small conchotome the inner wall of the nasal duct is bitten away to the level of the rim of the inferior turbinate. The fourth step consists in the removal of the inner half of the sac and of the inner wall of the soft tissues of the nasal duct. The first is accomplished with scissors and forceps, and the second with a conchotome. It is essential to leave the outer wall of the sac, for in this the common punctum is placed. In distended sacs this is seldom endangered, but in small sacs care must be taken not to injure this punctum. The mucous membrane of the nasal cavity is removed where it presents in the bony window, and is trimmed flush with the edges of this window. The region of the nose opposite this opening is made free from tags of the middle turbinate, and from anterior ethmoidal cells, for through this the punctum now drains. This is done in order that the granulations which occur during the healing process will not encroach upon the bony opening and seal it off.

Porter modified this by suturing the periosteum of the ascending process of the maxilla to the anterior lip of the sac. Other operators, also, have omitted the resection of the anterior tip of the middle turbinate. Mosher states that he is not as yet convinced of the wisdom of this (The author concurs in this opinion.) His operation differs from the original Toti operation in that he makes no attempt to join the lacrimal sac to the nasal mucosa, but makes equal and opposite openings in them both and anastomosing these openings with sutures. The Toti operation preserves the sac, while in the Mosher operation only the essential outer wall of the sac is saved.

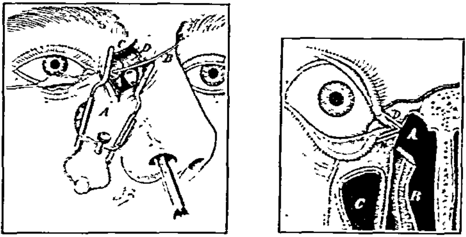
Wright,[1] who also is much in favor of dacryocystorhinostomy, especially in large dilated sacs, has a very clever means of assuring an intact nasal mucosa so that the osteotomy will not damage the nasal mucosa, making possible an easier anastomosis between the sac wall and the mucosa A fairly large window of bone is removed from the floor of the fossa by introducing a small, flattened, blunt hook through a dehiscence of the suture line in the lacrimal bone and using it to separate the nasal mucosa from its deep aspect. The hook is then employed to pull off a scale of bone toward the operator. This will permit very satisfactory flaps in the nasal mucosa for any subsequent use desired by the operator.

The integrity of the osteotomy is maintained undoubtedly by the soft tissues of the lacrimal sac and of the nasal mucosa which lie in the osteotomy and by their presence prevent the bony closure of this window. Nature normally attempts to maintain the strict, normal, skeletal configuration. It is well known that the interposition of soft tissue between bone fragments stops bony union, and is a principle frequently utilized by the orthopedic surgeon.

Failures occur from several commonly committed but preventable errors: (1) suppuration will cease but epiphora will continue in the presence of a slit canaliculus; (2) trauma to the remaining lateral wall of the sac will result in contraction and the reformation of a pinched-down, contracted

[1] *Lancet*, ii, 250, July 31, 1937.

pseudo-sac with the resulting closure of the osteotomy; (3) the osteotomy must be continued into the medial wall of the lacrimal-nasal duct, so that a lake of suppuration does not continue below the level of the osteotomy in the dependent portion of the lacrimal sac and the superior portion of the lacrimal-nasal duct. (Fig. 90 *A*, from the author's article on the Mosher-Toti dacryocystorhinostomy[1] shows the operative field of the rhinostomy and Figure 90 *B*, a diagrammatic cross section of the tissues resected, and Figures 91, 92, 93, show the formation of the osteotomy, the resection of the medial wall of the sac, and the catgut sutures into the sac.) (4) Before the dacryocystorhinostomy is done the nasal cavity on that side should be carefully inspected by a competent rhinologist. Chronic ethmoiditis should be corrected, first polypi must be removed, and an enlargement of the middle turbinate will necessitate an earlier removal of its tip; (5) an atrophic rhinitis is a contraindication; (6) errors in the postoperative toilet of the wound even before the skin is closed. The preliminary operation packing



A *B*

FIG 90.—*A*, the operative field for the Mosher-Toti operation; *B*, schematic drawing to illustrate tissues removed in the osteotomy *A*, is the position of the window; *B*, the inferior turbinate *C*, the maxillary sinus, *D*, and *D'* the canaliculi.

should be removed from the nose and repacked, the first strip passing up into the osteotomy window, so that it may be seen there and withdrawn in part to identify its presence. A second piece of packing is to be placed beneath the inferior turbinate to prevent the swallowing of any secondary hæmorrhagic seepage.

The first packing is removed after twenty-four hours, the second packing on the third day; at that time irrigation is done through the canaliculus. Every four hours, thereafter, adrenalin in oil is to be instilled into the nostril, with the head tilted back. The irrigation is done two or three times on alternate days and then at weekly intervals until complete healing has occurred within the nose. The adrenalin or ephedrine in oil must be continued after healing has occurred until no more nasal crusts are being formed.

Fistulæ which are present before the dacryocystorhinostomy need no subsequent attention. They cease to drain immediately, as in the cystec-

[1] Arch. Ophthal., 4, October, 1930.

tomy, and are healed within forty-eight hours. Occasionally it is necessary to resect the dimpled external orifice of these fistulæ at some later time.

In all of these cases a preliminary lipiodol injection should be made through the canaliculi into the sac, and roentgen-ray photographs made for subsequent study. The lipiodol shadow shows readily a complete occlusion of the lacrimal-nasal duct and will also show the oil going into the nose if the duct is at all patent; and further, will assist decidedly in identifying the presence of osteitis.

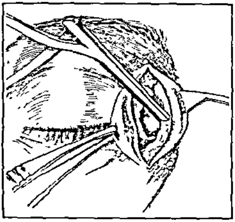


FIG. 91.—The osteotomy with punch forceps

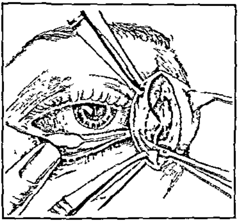


FIG. 92.—The resection of the medial wall of the sac

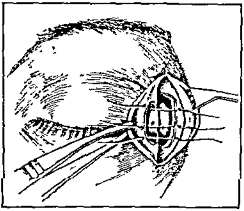


FIG. 93.—Catgut sutures from periosteum to lacrimal sac edge.

Arganaraz[1] in discussing the treatment of chronic dacryocystitis and lacrimal-nasal fistulæ considers his indications for the Toti operation to be: (a) chronic dacryocystitis with mucocele of the lacrimal sac which has not been complicated by acute pericystitis; (b) absence of obstruction to the lacrimal passages by scar tissue and definite permeability of the passages; and (c) freedom of the nasal cavities from any kind of acute or inflammatory processes. Arganaraz feels that deformities and deviations of the septum render impracticable the West-Polyak operation and require preparatory operation some days before the main operation. In the majority of the

[1] Am. Jour. Ophth., Series 3, 15, December, 1932.

cases it is necessary to perform submucous resection of the nasal septum to allow of access to the operative field, since in almost 80 per cent of the cases there is septal deviation. Fraser (of London), performs in the majority of cases a submucous resection of the nasal septum just before the operation on the tear sac. Also, he uses a small drill or trephine activated with the hand or with a small electric motor. Either one allows of making an ample bony window without pain or concussion.

Stock,[1] since 1929, has been utilizing a modified Toti operation for cases of chronic obstructive suppurative dacryocystitis. The operation consists in freeing the tear sac below after the usual skin incision as for removal. The tear sac is cut at its lower edge and retracted forward, this exposing the bed of the lacrimal fossa. A burr is used to produce an opening into the nose, and the sac is pulled into this opening, with two sutures at the lower end of the sac holding it in place within the nose during healing. These come out through the nostril and are held against the cheek by adhesive. Stock claims over 80 per cent of recoveries for his procedure.

MacMillan's[2] operation, presented prior to that of Stock's, similarly is a transplantation of the lacrimal sac, but in its entirety into the nasal mucosa. The author has had no experience with it, but MacMillan's results have shown a very high percentage of complete recoveries. His technique as he presented it is as follows.

The operation is carried out under local anesthesia. A line is taken between the infra-orbital foramen and the inner canthus, and 2 cc. of a 2 per cent procain hydrochloride-epinephrine solution is injected at about the junction of the lower and middle thirds of this line, which catches the branches of the infra-orbital nerve going to the region of the lacrimal sac. About 5 minims (0.31 cc.) of the same solution is injected subcutaneously, fairly high up, in the inner angle of the orbit to catch the supratrochlear and infratrochlear branches coming down. A pledget of cotton wool, placed in a 10 per cent solution of cocain and epinephrine and squeezed dry, is inserted high up under the anterior end of the middle turbinate. It is also well to give a hypodermic injection of morphine, $\frac{1}{4}$ grain (0.0162 gm.) before the operation. The skin incision, from 12 to 15 mm. in length, is made extending from the median palpebral ligament down and slightly outward, following the direction of the anterior lacrimal crest. As this crest is continuous below with the orbital margin, the direction is easily followed. The orbicularis muscle is then split, exposing the sac covered by fascia. The median palpebral ligament and its attachments are an infallible guide as the sac lies immediately behind it. The further dissection is carried on below the ligament, which is left intact, thus also sparing the canaliculi. After the sac is well exposed it is freed anteriorly and posteriorly by dividing the fascia. In large dilated sacs the procedure is easy as the fascia is much thinner, while in narrower sacs one has to divide the fascia vertically along the anterior and posterior crests, allowing it to remain attached to the outer wall of the sac. This is left *in situ* to hold a suture which is to be inserted. The sac is now freed down to the entrance of the canal, where it is cut completely across. A stout silk suture is then passed through the fascia and the outer wall of the sac and the sac is lifted upward with a retractor so that the lacrimal fossa is exposed. An opening is next made into the nose through the fossa. As a rule, a portion of two bones constitutes the fossa, the anterior by the frontal process of the superior maxilla, which is dense, and the posterior part by the thin lacrimal bone. A punctum dilator easily perforates the lacrimal bone high up near the median palpebral ligament, and it is then enlarged with the blunt end to a size big enough to admit the sac (from 3 to 4 mm. in diameter). Both ends of the silk suture can now be passed through the opening into the nose and picked up by a pair of nasal forceps. This is often difficult, as the opening is high up under the anterior end of the middle turbinate. I have found it easier to pass a fine filiform bougie through the opening

[1] Klin. Monatsbl. f. Augenh., 92, 433, April, 1934.
[2] Arch. Ophthal., 8, December, 1932.

so that it slips backward under the middle turbinate and appears in the pharynx. A rubber catheter is now passed through the nostril of the same side until it also reaches the pharynx. (Fig. 94.) Both are withdrawn from the mouth and tied together. On drawing the catheter from the nostril it is followed by the filiform bougie and then the suture which has been tied to it. Once the suture comes out of the nostril it is drawn firmly and the sac is inserted into the new opening. By tying the two ends of the suture over a piece of gauze, inserted into the nostril for the purpose, the sac is held in the opening. Three skin sutures are inserted, a pad of gauze is placed over the incision, and a firm bandage applied. The plug in the nose may be changed on the second day to avoid odor, and removed completely on the fifth day, when the sac suture may also be withdrawn and the skin sutures removed. The lacrimal syringe may be used, but if all is clean about the wound, this may be left for another week.

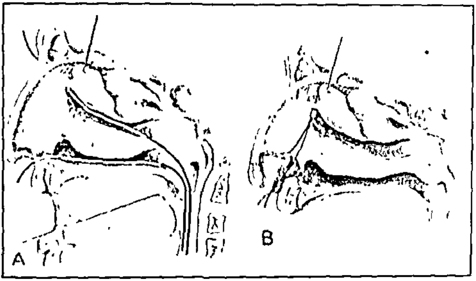


FIG. 94.—Lateral view with bougie in place, and with sutures on the lower part of sac, now within the nasal cavity. (MacMillan.)

Another operation for epiphora described by Stallard[1] is to be seriously considered, especially in a chronic suppurative obstructive dacryocystitis following traumatism to the lower internal canthal angle and/or across the nasal bones into the lacrimal-nasal sac. Bothman[2] suggests the name conjunctival dacryocystotomy for this new procedure. The technique as presented in the Year Book of Eye, Ear, Nose and Throat for 1941 in abstract follows herewith. (The author has carried out the procedure several times in traumatic cases and it has been universally successful in correcting the major portion of that constant epiphora connected with these cases.)

Under local anesthesia, the lacrimal sac is exposed through the classic incision for a dacryocystectomy. The fundus of the sac is freed from the adjacent tissues by blunt dissection and, together with the medial wall of the sac, is separated from the lacrimal fossa throughout its length. The lateral wall of the sac is dissected free from fibrous tissue—the result of the traumatic lesion—for about half of its length. A suture of No. 1 black silk is passed through the summit of the fundus, and the sac, thus mobilized, is

[1] Lancet, 2, 743-744, December, 1940.
[2] *Year Book of Eye, Ear, Nose and Throat*, 1941.

drawn laterally and slightly forward to ascertain whether it can be moved into the inner canthus without tension.

An oblique stab incision 5 mm. long is then made, with a double-edged knife, in the lacus lacrimalis (Fig. 95) and is carried through the connective tissue at this site downward, medialward and slightly backward, aiming at the center of the lacrimal fossa. The knife is withdrawn, and a pair of plain iris forceps is passed through between the lips of the incision; these emerge in the lacrimal fossa and are used to grasp the stitch in the fundus of the sac and to draw it into the lacus lacrimalis. The sac is then gently retracted laterally and forward so as to expose the orbital fascia behind it. This is incised vertically to allow orbital fat to herniate into the lacrimal fossa and to form a soft pad occupying the space between the new oblique position of the sac and the bony wall of the lacrimal fossa (Fig. 95, *C.*)

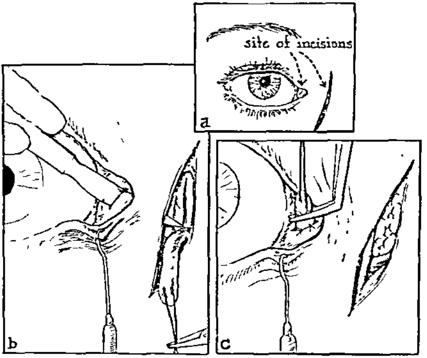


Fig. 95 —The Stallard transplantation of the lacrimal sac.

The sac is drawn upward and outward through the incision until 3 mm. of the fundus is projecting into the inner canthus. It is essential that the sac should not be under tension or kinked but should lie in an inclined plane downward, medialward and backward. A fine plastic hook is inserted into the lower punctum, and traction is made downward to evert the lower lid margin near its termination at the inner canthus, thus exposing the sac and the edges of the conjunctival incision. Four sutures of 000 black silk on half-circle arterial needles are inserted through the wall of the lacrimal sac and the conjunctiva midway along the posterior and anterior lips of the conjunctival incision and at its medial and lateral extremities. This done, the summit of the fundus is cut off, and the patency of the sac and nasolacrimal duct tested by gently passing a probe. The incision for exposure of the sac is then closed by a subcuticular stitch of silk and a light dressing applied.

EXTIRPATION OF THE LACRIMAL SAC

This may be done under local or general anesthesia. If under local anesthesia nerve blocking should be carried out as well as infiltration of the skin, also a few drops of 4 per cent cocain should be injected into the lacrimal sac itself. The anterior lacrimal crest should be identified, and an incision 2 cm. in length, made over this. Its upper third will cross the end of the internal canthal ligament. The essentials of Meller's technique follow, see Figure 96 *A*, *B*, and *C*. After the incision, a lacrimal speculum is introduced, the fibers of the orbicularis are split, and the fascia, which

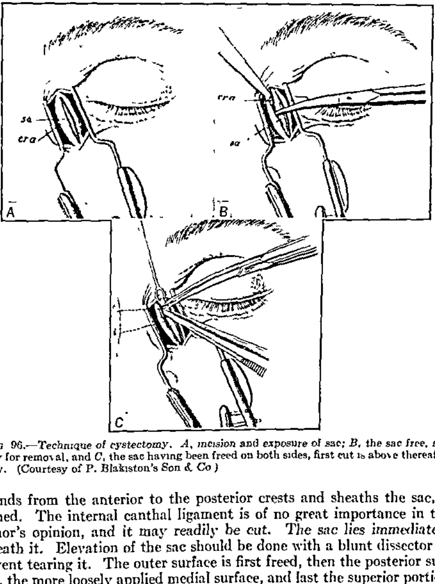


Fig 96.—*Technique of cystectomy. A, incision and exposure of sac; B, the sac free, and ready for removal, and C, the sac having been freed on both sides, first cut is above thereafter below.* (Courtesy of P. Blakiston's Son & Co.)

extends from the anterior to the posterior crests and sheaths the sac, is opened. The internal canthal ligament is of no great importance in the author's opinion, and it may readily be cut. The sac lies immediately beneath it. Elevation of the sac should be done with a blunt dissector to prevent tearing it. The outer surface is first freed, then the posterior surface, the more loosely applied medial surface, and last the superior portion of the sac as it lies in the dome of the bony bed. If the medial surface is first freed the sac is frequently torn in removing it from the more adherent temporal side of the lacrimal fossa. It is often necessary to use sharp dissection here, with small bites with dissecting scissors, to release it. The common punctum is cut across early in the dissection. With the sac now

freed in its entirety, it is pulled upward and outward and cut from the lacrimal-nasal duct as far down as it is possible to reach with scissors. The writer concurs with Greenwood in his recommendation of occlusion of the canaliculi by clamp and by resection, through the external lip of the wound. The last thing to be done is to curet carefully but thoroughly the mucous membrane of the lacrimal-nasal duct. The lacrimal fossa may be wiped out before skin closure with a weak iodine solution or with a weak solution of trichloracetic acid. The skin should be closed with an intradermic dermol suture. If contamination of the fossa has occurred, primary healing will not result. Adequate drainage from the fossa will occur for a few days through the curetted opened lacrimal-nasal duct, though this closes off wholly as healing progresses. The points which are difficult and important are: (1) the identification of the sac proper, and the blue tint which it has should simplify this; (2) sectioning the canaliculi; these can be seen adherent to the sac in its upper third as a dark blue cord; (3) removing the dome of the sac, in that a sharp hæmorrhage may occur at this place; (4) the careful and adequate resection of the sac from the superior extremity of the lacrimal-nasal duct. If the sac is torn during its extirpation, the operation becomes decidedly complicated. Tags of the sac wall may remain in the fossa, and the skin incision cannot be closed with an intradermic suture. Interrupted sutures must then be used in that primary healing will not occur.

The postoperative dressing following a cystectomy should have a pressure bandage applied, a moistened ball of gauze should be placed in the inner angle immediately over the site of the lacrimal fossa to obliterate the fossa, to prevent hæmorrhage within the fossa, and to obtain primary healing. Preëxisting fistulæ usually need no additional treatment, they should close promptly If the sac has not been well removed, suppuration will continue, primary healing will not occur, and a fistula if present will not close. In such instances the wound must be reopened and the sac completely removed Undiagnosed osteomyelitis of the floor of the lacrimal fossa may be found in a few instances as the cause of continued suppuration. In such instances, the entire area of diseased bone must be removed, remaining extranasal if possible, though it the nasal mucosa should be opened, it is not especially serious. Preoperative lipiodol injection and roentgen-ray studies should have been made to eliminate possible osteomyelitis.

Wright in discussing external extirpation does not cut directly upon the periosteum of the lacrimal crest but to the nasal side of it, otherwise he carries out Meller's classical technique.

Harrison Butler in 1911 presented his modification of a lacrimal sac extirpation, a technique which the writer follows with satisfaction. Local anesthesia is used in the largest number of cases, the skin incision is in the form of a half circle, the concavity facing the canthal angle. This crescentic flap is lifted by sharp dissection toward the angle and the palpebral ligament identified. The deep fascia is now split as is usual, and the sac freed from its bed with small blunt-pointed scissors before the canaliculi are severed, it is pushed down from above underneath the ligament, the canaliculi then cut and the sac removed from the duct as previously described. In cutting the canaliculi, too much traction must not be made upon the sac, otherwise the lids may be buttonholed. Several authors have

recommended the use of the strabismus hook to assist in elevating the sac from its bed.

Obliteration of the cavity of the lacrimal sac is a permissible procedure in acute dacryocystitis in the aged and in the infirm. The suppurative process is first incised with a sharp scalpel and with a vertical incision starting from the mid-line of the inferior border of the anterior canthal ligament. The blade is pushed in until the bone is touched, and the incision is completed after withdrawing the knife very slightly so that the posterior wall of the sac will not be incised at that time. The wound is extended downward and slightly outward for 1 cm. The contents of the sac are washed out and the sac is packed firmly with gauze for twenty-four to forty-eight hours. This packing is then removed and the actual cautery used under local anesthesia against the wall of the sac and down to the junction of the lacrimal sac and the lacrimal-nasal duct.

Hulka[1] feels that his improved technique for resection of the lacrimal sac renders an otherwise bloody and technically difficult operation, a simple and clean procedure. The technique of Hulka's operation is as follows: Infiltration with 1 per cent procain with 1 to 20,000 adrenalin solution is begun at the supra-orbital notch and is continued rather close to the periosteum along the inner orbital margin. The infiltrated and bulging tissues are then massaged to bring them back into their original anatomical relations. The anterior ridge of the lacrimal fossa can then easily be palpated with a finger. A fine hypodermic needle is plunged into the lacrimal fossa above the fundus of the sac. That is the region where, in the later stage of the operation, bleeding usually occurs. The point of insertion is about 3 mm. above the inner canthus and from 3 to 5 mm. temporally from the upper end of the palpable anterior lacrimal ridge. The needle should point toward the opposite ear. After the point hits the bone, the needle is inclined toward the opposite mandibular angle. After a little palpation with the point, it can be felt passing between the fundus of the sac and the lacrimal fossa. A few drops of the solution are then injected The anterior lacrimal crest is again located with the finger, and its course is marked into the skin. The incision is made 3 mm. nasally from this. The direction of the scalpel is perpendicular to the nasal wall, and the scalpel cuts deeply into the tissues to divide them down to the periosteum The length and shape of the line of incision are usually described as beginning from 2 to 3 mm. above the canthus and running parallel with the curvature of the orbital margin. The incision should not be more than 3 mm. distant from the anterior lacrimal crest, because about 5 mm. nasally from the crest the angular vein and artery are located. There is usually some bleeding from the upper end of the incision which can be promptly controlled by hæmostasis. No retraction is done toward the nasal side, and little or no retraction is necessary toward the ocular side. The soft tissues are separated from the periosteum and pushed toward the eye. The elevation of tissues proceeds then toward the lacrimal crest and over the lacrimal sac. The best instrument for this procedure is the blunt end of Stevens scissors. In the process of separation the rigid canthal ligament remains attached to the bone, so that the most important landmark for further dissection is easily and clearly identified. In order to elevate the sac from the fossa, one begins at the fundus above the canthal ligament. The attachment formed

[1] Arch. Ophth., 14, 110, July, 1935.

in this place by rigid fibers is best divided close to the periosteum with an old cataract knife. If the injection needle is properly plunged into this region, there is little bleeding even during this part of the operation. The nasal side of the sac is then separated from its bed by blunt dissection, and finally, with the sac fully visualized and identified, the canthal ligament is divided.

Hildreth[1] has had decided success in the surgical diathermy extirpation of the lacrimal sac wherein lacrimal sac extirpation is necessary but at the moment impossible. He believes the actual cautery would have been the instrument of safety a few years ago but the resultant burning is unnecessary, the scars unsightly, and the cutting diathermy current seems to fulfill ideally the requirements of safety and effectiveness. The diathermy knife cuts with no trauma, the tissues divide actually ahead of the moving knife in a melting-like process effected by the heat of the electric current. The entire operation may be done without the use of forceps, the knife and the wire loop being the sole instruments.

RESTORATION OF LACRIMAL DRAINAGE

In 1925, J. F. Callahan[2] presented a paper entitled Restoration of the Lacrimal Passages after Excision of the Lacrimal Sac. Spratt[3] states: "Since reading that paper the use of the Callahan tubes has been my only method for treatment of lacrimal obstruction and chronic dacryocystitis." The use of tubes was suggested by Walthen of England, who, in 1781, proposed the insertion of hollow gold and silver tubes with flat heads to hold them in place. Callahan has contributed to the operation as follows: (1) The introduction of a soft silver tube with thin walls into the duct on a Theobald or Ziegler probe which served as an obturator; (2) the removal of the tube through the nose by grasping the lower end where it rests beneath the inferior turbinate. In certain cases, an entirely new duct was formed, even after the excision of the sac. The operation can be completed under nitrous oxide in from three to five minutes. (3) The tube may be introduced after the method of Agnew, directly from the conjunctival angle through an incision into the lacrimal sac. Measurement is made on the probe as it rests on the floor of the nose beneath the lower turbinate so that the upper end in the lacrimal sac is at about the level of the lower canaliculus. The tube is cut to the proper length, and a little lubricant is placed on the probe. As this silver tube is no thicker than ordinary paper (the walls being approximately 0.01 mm. in thickness) the introduction is easy. The lower end of the tube rests on the floor of the nose and the upper end is in the sac, slightly below the level of the lower canaliculus. The tube is left in place from six months to one year. The removal is easily accomplished: After anesthetizing the membrane of the nose with cocain, the lower end of the tube is grasped with a slender hemostat. This is rotated on its long axis, and the tube being thin-walled and of soft silver, is wrapped about the hemostat. This operation gives the patient relief both from the epiphora and the infection and is quickly and painlessly done. In case the operation should prove unsatisfactory, the tube may be reintroduced. In traumatic obstruc-

[1] Am. Jour. Ophth., Series 3, 19, 699, August, 1936.
[2] Arch. Oto-laryngol., 1, 127, 1927.
[3] Am. Jour. Ophth., Series 3, 19, 602, July, 1936.

tion, a new duct can be formed. Spratt treated 65 cases by this method, with but 3 failures. In 1, there was entire absence of the infection but stenosis has occurred at the upper part of the sac. The other 2 cases were caused by trauma following automobile accidents. All 3 were so situated that the proper treatment could not be continued.

Lead styles, not tubes, are of value, occasionally in lacrimal canaliculus strictures; these may be worn for from six to ten days. The use of lacrimal styles, however, for chronic obstructive dacryocystitis is to be condemned. They demand a slit canaliculus, or result in one through the trauma from a long contained style. Other operative procedures already discussed are far more effective without demanding or causing this unnecessary defect.

RECAPITULATION OF LACRIMAL SAC THERAPY

Acute Suppurative Dacryocystitis.

Infants.—Do not incise. Irrigations and probing.

Young Children.—Irrigation through puncti. Probing with small probes. Anti-streptococcus and anti-pneumococcus sera Nasal mucosa shrinkage, of special value in children because of the short duct. Compresses of magnesium sulphate, saturated solution and glycerine, equal parts. Sulfa drug.

Adults.—Same as above. In addition incision and drainage of the sac. Three procedures, with and without sulfa drugs locally.

1. Incision and packing into the sac.
2. Incision and packing through the nasal mucosa after incision through the bone of the lacrimal fossa with dental burr and of the mucosa with a scalpel.
3. Incision and packing through the lacrimal-nasal duct, applicable to primary attacks as a frequently successful attempt to conserve the ultimate patency of the duct.

Chronic Suppurative Dacryocystitis.

Cystectomy or Cystorhinostomy.—The indications for the one are the contraindications for the other.

Cystectomy.—Indications.

Tuberculosis of the lacrimal sac.
Tuberculous osteomyelitis.
Malignancy.
Chronic atrophic rhinitis.
Chronic suppurative ethmoiditis. (This may be corrected to permit cystorhinostomy later.)

Cystorhinostomy.—Indications.

Subsequent intra-ocular surgery can be done readily and safely after a successful cystorhinostomy.

Suppurative with mucocele. Acceptable procedures.

1. Mosher-Toti.
2. Halle-West procedure.

Suppurative without mucocele.

1. MacMillan's technique.
2. Mosher-Toti.

Chronic obstructive, without suppuration.
1. Sea-tangle probes.
2. MacMillan's technique.
3. Mosher-Toti.
4. Traumatic obstruction.
Stallard's transplantation of the sac.

Congenital Absence of Sac.—Seen with other congenital defects.

Rhinostomy, Late Following a Former Cystectomy.—See preceding text for author's method and that of Arruga.

Traumatic Laceration of the Canaliculi, Early and Late—See preceding text for method recommended.

Procedures Condemned, except under most extraordinary circumstances.
1. Rapid dilation of the lacrimal-nasal duct.
2. Slitting the canaliculi.
3. Styles other than for.
    1. Congenital absence of the sac.
    2. Reconstruction of traumatisms.
    3. Temporarily because of the recurrence of suppuration after cystorhinostomy.
    4. As tubes in inoperable cases of chronic obstructive dacryocystitis.

CHAPTER IV

ENUCLEATION AND ALLIED OPERATIONS

ENUCLEATION

The problem of indications for enucleation, evisceration, or orbital exenteration is at times a rather difficult one. It must be distressing for a young and, or, relatively inexperienced ophthalmologist to recommend an enucleation—the indications seeming to be adequate for this—only to fail in having this recommendation concurred in by an older and perhaps more experienced consultant. The reverse of this would probably be more uncommon. A second point for serious consideration is the advisability of some other operation as a substitute for the enucleation, and third the positive indications which are present in certain cases against enucleation and in favor of evisceration. Exenteration of the orbit is uncommonly necessary, but when indicated it must be carried out

Several authorities, in discussing these factors, have subdivided the indications into: (1) those which are absolute and imperative, also rather likely immediate; (2) a second group which are more or less elective and not immediate; and (3) a group wherein the indications are definitely optional and largely for cosmetic reasons. Meller's imperative indications for enucleation are threefold: (1) a painful eye with the vision irretrievably lost, (2) the possibility of a sound eye being seriously endangered by sympathetic ophthalmia; and (3) the presence of an intra-ocular malignant neoplasm There is much to be said at the present time against the imperativeness of his third recommendation, still one should not temporize long in the presence of a unilateral pigmented sarcoma of the uveal tract in an individual who has a sound eye in the opposite orbit. (Similarity, bilateral enucleation is not always indicated in the presence of bilateral retinoblastoma of the infant.) It is wise to add some additional indications to those above, though perhaps they are already included in the three major premises mentioned. For instance, episcleral and epicorneal malignant growths may need enucleation. Extreme phthisis bulbi does not always come within the scope of optional enucleations. Enucleation, or some substitute for it, is indicated shortly after postcataract extraction subchoroidal hæmorrhages. The period of convalescence is appreciably shortened. Suppurative panophthalmitis must be drained. We know, from the surgical anatomy of the globe, that an enucleation opens the meningeal spaces, therefore, evisceration is in this instance an imperative substitute for enucleation. The treatment of cavernous sinus thrombosis demands enucleation unless the surgeon feels it can be combated successfully in some other manner. Retrobulbar neoplasms, especially those accompanied by blindness from an optic nerve atrophy, or when the problem is saving the patient's life, are properly treated by an enucleation or even an exenteration. Beard includes in this, grave phlegmon of the orbit when sight is utterly destroyed, and operation may aid in curing the disease.

Elective indications are not always imperative and usually not immediate. Perhaps the first of these is the eye of absolute glaucoma. Cer-

tainly, intra-ocular surgery for these blind and frequently staphylomatous eyes is folly. Such eyes as a rule should be enucleated. Recent injuries, extensive and perforating of the sclera, involving the ciliary body (see Section on the Surgery of the Sclera) are certainly included here even if not where absolute indications apply. This also applies to phthisis bulbi, to staphylomata of the cornea and of the globe, to atrophic eyes blind from a chronic iridocyclitis, and to eyes blind as a result of retained intra-ocular foreign bodies. The presence of pain in these, either as a chronic symptom or as a constantly recurrent symptom, is likely the outstanding point in the election for an enucleation. Beard includes acute suppurative panophthalmitis in his classification of elective indications. The writer believes it should be included within the absolute and imperative indications. The prevention of one case of metastatic meningitis is far more important than the retention of many sightless eyes wherein enucleation is declined because of cosmetic reasons. In surgery, it is an absolute law that suppuration must be drained. The optional indications are based almost wholly upon their relationship to the cosmetic appearance of the patient. Eyes normal in every detail except for a total leukoma of the cornea can be improved decidedly by tattooing, though sympathetic ophthalmia has followed this procedure. Further, a satisfactory procedure for corneal transplantation is now available, and conservation may be of importance, later on. In general, unilateral or bilateral blindness, in which an enucleation would materially improve the patient's appearance, his earning ability, and not endanger subsequent possible chances for improved vision may be considered in this class of optional enucleations.

General Indications Recapitulated.—In general, the three operations to be considered are, the Mules' operation which is an evisceration of the scleral shell with retention of the shell as a collapsed fibrous nodule for a stump; Dimitry's, in its simplest form is the implantation of some foreign body (for permanent retention) in the scleral shell; and the Frost-Lang technique which is the implantation of some permanent foreign substance into Tenon's capsule. Evisceration, as proposed by Noyes in 1873, was later modified by von Graefe in 1884. In 1885, Mules advised his evisceration and, in 1916, Dimitry[1] modified an original technique of Huizinga. The Frost-Lang technique was separately advised by Frost[2] and by Lang.[3]

In general, enucleations (see page 130) apply in all instances except those in which evisceration or exenteration is indicated.

Exenterations.—A retrobulbar malignancy especially if recurrent, and when primarily or metastatically attacking the bones or the margins of the orbit, is perhaps the one certain indication for this operation. If the surgeon can satisfy himself, with reasonable assurance, at the operating table that the malignancy has been removed, the operation must be completed at that time with skin flaps and grafts. Radium and roentgen-ray therapy cannot be used thereafter in such circumstances until after the healing is complete from these plastic corrections. If these flaps are exposed to earlier irradiation they may die. If the operator cannot satisfy himself as to these indications, the orbit must be left as a raw and painful open wound. From a prognostic standpoint this is always serious. In

[1] Jour. Am Med. Assn., 35, 394, 1900
[2] Brit Med Jour., i, 1153, May 28, 1887
[3] Trans Am Ophth. Soc., Unit. King, 7, 286, 1887.

such instances the wound must be covered with oiled silk and packed lightly, but with sufficient packing to hold the oiled silk in contact with the bared bone.

Evisceration.—The rather definite indications for eyeball evisceration are, acute suppurative panophthalmitis, extensive injuries of the globe especially in the aged, and following postoperative rupture of the eyeball especially when accompanied by severe subchoroidal hæmorrhages, with prolapse of the vitreous and the uvea. Repeatedly, operations have been advised for the implantation of a sphere of some type into the scleral shell. The reason given for these operations is that motion of the stump is thereby increased and the cosmetic appearance of the patient improved. Practically, the author cannot concur in this. The postoperative course is never as uneventful, the reaction is more marked, the period of hospitalization is greatly increased, postoperative extrusion of the sphere (whatever the sphere may be) is much more common, and the final stump is actually smaller than that obtained by other procedures. The scleral shell cannot contain a sphere of a size equal to one implanted into Tenon's capsule Amputation of the anterior segment according to Critchet for anterior staphylomata and total staphyloma of the cornea with removal of the uveal tract and a collapse of the sclera by fine sutures does give a fairly good stump and may under certain circumstances be indicated, but it is not an operation of choice. Enucleation of the globe is the indication in practically all of the other reasons for the removal of the eyeball. The enucleation may be either a simple one, or some modification of the Frost-Lang technique, that is the implantation of a foreign body sphere into Tenon's capsule.

Optico-ciliary Neurectomy.—An optico-ciliary neurectomy has been frequently recommended for painful and atrophic globes whereby, through the sectioning of the ciliary nerves, the globe becomes painless with a subsequent reduction in the chronic congestion. *The operation is indicated only as a part in the treatment of complete anterior symblepharon.* In *some of these cases where the conjunctiva, bulbar, palpebral, and corneal, has been completely destroyed, there is still the possibility of saving the globe itself as a satisfactory movable stump for the prosthesis.* In such *instances the symblepharon is to be corrected by reconstruction of the superior and inferior cul-de-sacs through the use of a razor cut Ollier-Thiersch epidermal graft* over a shell of dental stent. The operator must be satisfied *to know in these cases that vision can never be restored by any means. Considering this,* the optico-ciliary neurectomy is proper. A *mucous membrane graft,* in such instances, will retain light perception for the patient, but a prosthesis is not worn with full comfort in cul-de-sacs restored by mucous membrane where the eyeball, as such, is retained. If there is no hope for improvement of vision in the future, if the conjunctiva is completely destroyed, the eyeball itself has not been perforated, and the interstitial portions of the cornea are still healthy, then the surgeon may seriously consider reconstruction of the cul-de-sacs with epithelial grafts and the completion of the case with a neurectomy. Benedict recommends the advisability of a neurectomy in a blind eye, otherwise normal, and in the presence of exophthalmos from a non-malignant neuroma of the optic nerve.

Ocular Prosthesis.—The matter of an ocular prosthesis and the time when this is to be fitted depends largely upon the case. The same thing applies

as to the advisability of ordering a shell eye or a reform eye. In general, a simple enucleation can usually be fitted with a temporary reform eye, a week to ten days after the enucleation. A Frost-Lang operation may need a shell eye at first but a reform eye will probably be the permanent one ordered. This can ordinarily be fitted two to four weeks after the operation. An evisceration, especially one which was preceded by suppuration, will need from four to six weeks convalescence before a reform eye can be fitted. The same period, and in some instances one slightly longer, will need to elapse following a Mules' operation. It is relevant here to call attention also to the fact that following socket and cul-de-sac reformation an ocular prosthesis, at least a temporary one, may be fitted at the time that the stent is removed or the conformer exchanged for a shell.

The postoperative appearance following a Frost-Lang operation or a Mules' operation is usually excellent. The results are never as satisfactory after an evisceration, though they are equally good with those following a simple enucleation. Many cases of simple enucleation, done as such because of complications at the time, may be improved later by a delayed implantation into Tenon's capsule. Regardless of the length of time (it seems) which has elapsed since the simple enucleation, Tenon's capsule can always be reopened and utilized as an enveloping tunic for the retention of an implant. Naturally, if Tenon's capsule was destroyed at the time of the enucleation, this will prevent that operation. It is remarkable to reopen such cases even twenty years after the enucleation and find a healthy, flexible, and elastic Tenon's capsule for surgery.

Surgical Technique.—*Anesthesia.*—Eviscerations should be done under general anesthesia. Chloroform is satisfactory for infants though ether may be used and venethene as well. Venethene or ether is satisfactory for children and gas and oxygen for all except the aged. With these, ether and venethene are again perhaps the best anesthetic. Exenterations and neurectomies must be done under general anesthesia. That for an evisceration alone applies equally well to exenterations. The operation, however, is a longer procedure and may be followed by some shock. Therefore, avertin can be used in small doses, and augmented, as is necessary by the above. Simple enucleations can be done quite satisfactorily under local anesthesia. The conjunctiva is anesthetized by the instillation of cocain, Tenon's space and the muscle sheaths are ballooned out with novocain, and the retrobulbar structures completely anesthetized with a retrobulbar injection of novocain and adrenalin. In some of these instances gas and oxygen may be utilized for the actual neurectomy. This, if added, is to be started just before prolapsing the eyeball for sectioning the optic nerve and the oblique muscles. Enucleations, according to the Frost-Lang technique, demand careful surgical technique. Attention is, therefore, necessary to the anesthesia. Avertin, combined with novocain, is the anesthetic of choice unless there should be present some contraindications to the use of avertin. If such are present, ether may be substituted and if this is contraindicated then the operation must be done wholly under local.

Simple Enucleation.—The conjunctiva is incised as close to the limbus as is possible, undermined into the internal and external commissures and into the superior and inferior fornices, and it must not be buttonholed. Stevens' scissors are best for this. The four recti are then divided, the internal rectus first. This may be done by introducing a hook under the muscle and

cutting with Stevens' scissors against the sclera, or it may be done by means of a blunt-pointed angular scissors the opened blunt lower blade acting as the muscle hook. The superior rectus and the inferior rectus are tenotomized similarly. If the eyeball is phthisical it is possible to pick up the two obliques on a hook and section these as well. Under ordinary circumstances, however, this cannot be done. The external rectus is tenotomized last. This muscle is cut, with a small muscle tab adherent to the sclera, so that lock fixation forceps or a mosquito hæmostatic forceps can be clamped to this stump to control the eyeball in the subsequent enucleation. If this has not been done it will be necessary to introduce a braided scleral suture at the site of the stump, and to use this suture for traction. A Lewis type of tonsil snare is then threaded over the eyeball, the conjunctiva retracted from the eyeball and out of the wire loop of the snare, the loop partly closed, this pushed into the depths of the orbit and the eyeball prolapsed from the orbit at the same time by means of the forceps or with the suture. The snare is slowly closed and the optic nerve sectioned in this manner. The obliques offer some resistance at first to being cut with a wire snare, but if the closure of the snare is slow and gradual without jerking, the neurectomy will be uneventful. The snare renders the operation practically bloodless. It should not be used, however, in the presence of a ruptured eyeball nor with an eyeball which has weakened scleral or corneal tunics. Under no circumstances should the snare be jerked from the orbit One instance was seen where the operator damaged the chiasm by unnecessary and unusual violence with the snare while doing a simple enucleation If the snare cannot be used, enucleation scissors, introduced behind the eyeball while it is being moved into extreme internal rotation, and after it has been prolapsed, are used to cut the optic nerve and the oblique muscles In this way a long stump may be obtained. The snare will cut the obliques, the scissors, however, must cut these free from the globe after the neurectomy.

In completing an enucleation with enucleation scissors it is important to remember that the sclera is very thin behind the insertion of the recti. It is not at all rare for an inexperienced operator to cut through the sclera when doing a tenotomy with curved scissors. The complication is easily understood when one recalls that the sclera at the insertion of the recti tendons is only about 0.3 mm. in thickness. In this matter of thin sclera connected with enucleation, A. Fuchs[1] speaks of the importance of the regions of the optic disk.

In a myopic or a glaucomatous eye, and particularly in one in which the two diseases coincide, a circumscribed protrusion of the sclera in the vicinity of the optic disk may occur. This condition may be recognized also clinically It was described by von Graefe, and in a previous article I have illustrations from a number of cases observed clinically and histologically.[2] At the same time, not only the lamina cribrosa but also the adjacent portion of the sclera, which forms the roof of the vaginal fornix of the sheath of the optic nerve, are forced backward. The excavation affects an area three times as large as the optic disk. Especially to the right one sees how the roof of the fornix (r) and the adjacent parts of the sclera (s), on which the choroid and the retina have partially disappeared, are involved in the excavation.

If, in applying enucleation to such an eye, the scissors are pressed hard against the posterior pole and are closed when one thinks one has the optic nerve between

[1] Arch Ophth., 16, September, 1936.

[2] Am. Jour. Ophth , 7, 257, 1924.

the blades, it may happen that the protruding portion is cut off. Thereupon the contents of the eye run out, and one has only an empty sac in the forceps, which is difficult to excise. In addition, a portion of the eye remains in the orbit, and the histological preparation is ruined. I (A. Fuchs) once saw such a complication when an operator with great labor had had the head of a fibula taken from his patient (prepared by a surgeon) with the idea of implanting it in the orbit in place of the eyeball. When he then performed the enucleation he met with the aforementioned accident. He was of course compelled to probe deeply to discover the remainder of the eye and to extirpate it in order to implant the head of the fibula. In a similar manner the contents of the eye may run out if the excavation caused by secondary or absolute glaucoma extends far backward and the lamina cribrosa is recessed to an unusual degree. In cutting off the optic nerve, the operation on the nerve is performed correctly, but the lamina cribrosa that was bent backward is lopped off, and the contents of the eye escape.

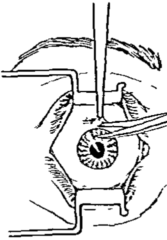


FIG. 97 —The dissection of the conjunctiva.

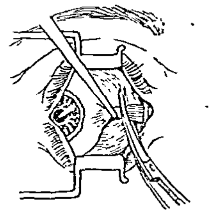


FIG 98 —Resection of a rectus muscle.

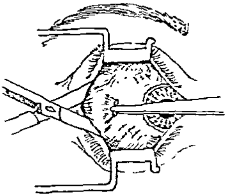


FIG 99 —Eyeball prolapsed and ready for the neurectomy.

The socket is to be inspected, hæmostasis completed and the conjunctiva closed with an untied running black silk suture (Figs. 97, 98, and 99). It is a good practice to place a small piece of plain oil impregnated or iodoform impregnated tape ($1\frac{1}{2}$ inches) into the conjunctival cul-de-sac overlying the line of the sutures, and protecting them from the opened palpebral fissure. A Barraquer dressing is applied, in this instance monocularly, and bandaged with pressure All other things being equal, the dressing should not be disturbed until the fifth day. At that time the tape and suture are removed,

through and through with many perforations. Guist has recently given us the most satisfactory of all implants. It is a carbonized bone ball, marketed by several American and European firms. The disadvantages of metal balls with their smooth surfaces are eliminated in these. Formalized calf cartilage (used frequently by the author) has difficulties connected with its sterilization and with its subsequent deformalization, and ivory balls are also difficult to sterilize. The author once had the opportunity, however, of removing one of these, at postmortem, five years after its implantation and forceps and scissors were necessary to separate it from the fibrous tissue which had grown into these perforations and had made it an integral portion of Tenon's capsule and the ocular muscles. The only disadvantage that the carbonized bone ball has as is now used, is that it is rather fragile and must be carefully handled while being implanted. Preference thus seems to be as follows: all other things being equal, the carbonized bone, first; ivory, second; decalcified bone, third (difficult to obtain); formalized cartilage, fourth; and the gold, Mules' spheres, last. With these possibilities at our command there is no reason why other strange and individual implants should even be considered.

Formalized cartilage is the only one of these which needs extensive preoperative preparation. The carbonized bone ball and the decalcified bone ball may be sterilized in the autoclave. The gold and glass Mules' spheres may be boiled in an ordinary sterilizer. Ivory balls should be placed in a sterilizer filled with cold water and the temperature of the water brought up gradually. After it has reached the boiling-point the ivory balls should be boiled for one-half hour at least.

Cartilage to be formalized may be obtained from any butcher. The large cartilaginous plate from a calf's scapula is cut from the carcass and subdivided into a number of smaller pieces each approximately 3 cm. square. The perichondrium is stripped from each piece and they are placed in a 40 per cent aqueous solution of gaseous formaldehyd (formalin). The cartilage is left in this solution until utilized. A minimum of five days is necessary. Cartilage has been used which had been in formalin for five years; for the length of time that the cartilage is in the formaldehyd solution, after the minimum of five days, is unimportant. Forty-eight hours before a piece is to be used it is removed from the fixative solution and placed in a flask of sterile distilled water. This should be frequently agitated and changed three times the first day, twice the second day and then brought to the operating table on the following day in a fresh flask. The piece of cartilage which is to be used should be thick enough that it can be cut roughly into a sphere which has four slight depressions on its edges corresponding to the position of the four recti, similar to the depressions for the recti muscles, to prevent late migration of the sphere, which Wheeler recommended. If the thickness of the piece of cartilage available is not sufficient, two thicknesses should be used and these two sutured together with sterile braided silk, in exactly the way one would sew a button upon a coat, that is, the two ends of the suture should be passed from one surface through the two thicknesses of the cartilage and then back again to the first surface where they are tied snugly and the ends cut short. The formalized cartilage can be cut quite readily with a sharp scalpel and it is a simple thing to trim it to the desired size and shape wanted. This all should be done at the operating table before the enucleation. As soon as

the surgeon is satisfied as to the size and the shape of his implant, it can be placed into Mules' sphere introducer and laid to the side. Carbonized bone, ivory spheres, and decalcified bone should be brought to the operating table wrapped in sterile gauze, gold and glass balls should be placed in a Mules' sphere introducer, this wrapped in gauze and the two sterilized together. This gauze-wrapped instrument should be placed upon the operating table and not opened by any one but the surgeon. Absolute sterility must be maintained for these implants. When the bone or ivory is ready for introduction into Tenon's capsule, the gauze in which they are wrapped may be opened and the balls placed into the introducer without being touched.

Frost-Lang Operation.—In general, avertin anesthesia combined with local anesthesia is the best in the largest number of cases Gloves should be worn by the operator and his assistants in these operations, for the conjunctival cul-de-sacs are not sterile, and in spite of an asepsis as rigid as it is possible to maintain, a low grade secondary infection and the subsequent extrusion from Tenon's capsule of the foreign body ball occasionally occurs.

In incising the conjunctiva about the limbus one should use at the start sharp-pointed scissors so that the sclera is immediately bared. The dissection can be continued with blunt-pointed scissors thereafter but it is important that Tenon's capsule be simultaneously lifted with the conjunctiva from the limbus. The same extensive undermining is necessary as in a simple enucleation. Many operators in handling the four recti, put a 3-0 catgut suture into each of the four recti before they are detached from the eyeball; the purpose being to draw these forward subsequently over the suture in Tenon's capsule. The author is now convinced that this is essential. If the muscles are cut free from the sclera with Tenon's capsule the subsequent purse string suture in Tenon's capsule, over the implant, will bring them forward into a satisfactory anatomical position. It is, however, something which each operator must individually decide

If the sutures are to be used, a generous bite should be taken in the external surface of each muscle, the suture immediately tied in a double knot, the ends of the suture clamped together in a pair of hæmostatic forceps and these laid to the side out of the way. A muscle hook lifts the internal rectus, the superior and the inferior recti away from the globe, and the muscle is then severed from the globe as closely as possible without perforating the globe and without disturbing its capsule sheath. The external rectus should have a tab of stump remaining attached to the globe for subsequent traction purposes. As soon as the four recti have been cut and laid to the side, with their sutures in place, closed curved scissors are passed about the sclera within Tenon's capsule so that the operator can be certain there are no inflammatory or other adhesions of the sclera to Tenon's capsule which would complicate the success of the coming implant into Tenon's capsule. A tonsil snare may be used for the enucleation here as in a simple enucleation. If scissors are to be used, either because a snare is not available or because the eyeball is in a weakened condition, then the eyeball is rotated nasally, the scissors introduced temporally, opened in the depths of the orbit, and the optic nerve cut with as long a stump as it is possible to obtain. As in a simple enucleation the obliques must then be cut, after the neurectomy, to complete the enucleation. A sharp hæmorrhage will usually follow after the use of the scissors. This

can be controlled promptly and the socket rendered dry by a few minutes of hot wet gauze packs. Occasionally it is necessary to use hæmostatic forceps and even sutures in the depths of the orbit to control the hæmorrhage. As soon as hæmostasis is completed, the edge of Tenon's capsule is grasped with three to four pairs of lock fixation forceps or artery clamps, and the capsule brought forward as an empty sleeve so it can be inspected and freed from any conjunctival adhesions which may be present (Fig. 100, *A* and *B*.)

The Mules' sphere introducer is then uncovered, with its contained implant, placed into the mouth of Tenon's capsule and without touching the implant, even with the gloved fingers, it is projected into the depths of the orbit. The introducer is then withdrawn and a purse string suture immediately placed into the edge of Tenon's capsule. If the implant tends to expel itself, either it is too large or there is still some hæmorrhage in the orbit. In the case of the first instance, a smaller implant must be used, in the second, as has already been stated, and again emphasized, complete hæmostasis must be acquired before the foreign body is implanted into Tenon's capsule. The purse string suture is readily passed, for the lip of

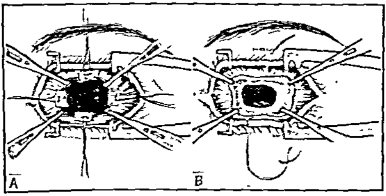


Fig. 100.—Tenon's capsule implant *A* forceps on the capsule, *B*, introduction of the suture

the capsule can be raised and the inner surface of the capsule exposed. It is to be carried about the circumference of the opening maintained with the lock forceps (Fig. 100, *B*), for the suture should lie on the inner aspect of Tenon's capsule, 3 or 4 mm. from the edge. If it is passed along the inside surface when it is pulled taut and tied over the implant, there will be a small everted cuff of Tenon's capsule lying above this suture, as a reduplication of the capsule. The size of the implant, the amount of capsule present, and the elasticity of the capsule itself all modify this in each individual case. After the suture is tied and before the ends are cut the operator must assure himself that the capsule is not torn, in any one place, and that the suture wholly encloses the implant. If muscle sutures have been used, the internal and external recti are now brought forward, folded over the closed capsule, and attached there with the sutures, through the upper margins of the overlying muscles, to the capsule, and then to the lower margin... The sutures, which were originally tied in the muscles, may be cut o... ...arded. The superior and inferior recti are similarly handled, the... ...d above the folded and overlapped ends of the internal and ... ...conjunctiva is then closed with interrupted fine black

silk twisted sutures. Before the lid speculum is removed a small piece of iodoform tape is placed over the line of sutures. A binocular dressing is applied, and not changed for five days, all other things being equal. The unoperated eye is covered for this length of time to hold the operated stump quiet and to allow healing by first intention. After five days the dressings are removed, the unoperated eye cleansed, the tape removed from the socket, and a second dressing applied for another two days. The first dressing should exert a fair amount of pressure over the operated socket to guarantee hæmostasis; the second dressing need not be applied as snugly. At the time the second dressing is changed, the sutures may be removed and the patient placed on hot compresses and cul-de-sac irrigation with warm boric acid to hasten the recession of the postoperative reaction. Under ordinary circumstances the patient may be discharged from the hospital shortly thereafter. The first or temporary prosthesis should not be fitted until this postoperative reaction has receded almost wholly.

In recent years the author has used almost wholly the charred bone spheres known in the trade as Guist's spheres. These carbonized bone balls prior to their insertion into Tenon's capsule are lightly heated in the flame of an alcohol lamp, and then while in this hot condition are plunged into Tenon's capsule and forced into position with the introducer. A slight amount of cauterization of the inner surface of Tenon's capsule occurs thereby with a much finer adhesion of the capsule to the implant.

The principal faults committed with the Frost-Lang type operation are the inadequate preparation of the implant (sterilization and its inclusion in a Mules' sphere introducer), rigid asepsis, every bit of conjunctiva which can be conserved must be saved to prevent subsequently a contracted socket; a satisfactory closure of Tenon's capsule is quite necessary, if muscle sutures are used the overlapping muscles must be well anchored into position; superfluous sutures, however, may nullify an otherwise satisfactory operation for catgut does not absorb rapidly in this operation, and the knots may cause small fistulæ, and even though they extrude themselves or are removed by the surgeon, extrusions of the implant may occur as a result. The conjunctiva, it seems, heals best when closed with interrupted sutures. These are certainly necessary if the conjunctiva seems deficient. Purse string sutures have been used in the conjunctiva by some with success, and by others an untied running black silk suture, with equal success. In so far as the size of the implant is concerned, it is seldom that one is used which is too large. A more common fault is the utilization of one which is too small.

Perhaps the most common fault connected with an enucleation is the lack of attention paid to the operative procedure. In many hospital clinics the Junior House Officer does the routine enucleations. This is not proper; the operation is far too important for such casual treatment. The cosmetic blemish which results after a poor enucleation is marked and can be prevented only by scrupulous care in the important essentials of the operation.

A sharp orbital hemorrhage is usual following a scissors-cut neurectomy. This may be minimized to a certain extent by introducing the closed scissors and feeling for the cord-like resistance of the optic nerve with the side of the scissors. Then the scissors are opened and this cord sectioned with one clean cut. Frequent blind cuts with the scissors will increase the hæmorrhage, will make it impossible to obtain a long stump, and it may

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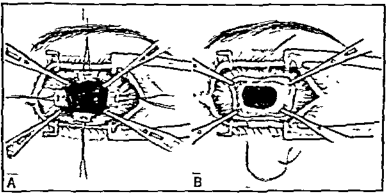

FIG. 100 —Tenon's capsule implant: *A*, forceps on the capsule; *B*, introduction of the suture

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silk twisted sutures. Before the lid speculum is removed a small piece of iodoform tape is placed over the line of sutures. A binocular dressing is applied, and not changed for five days, all other things being equal. The unoperated eye is covered for this length of time to hold the operated stump quiet and to allow healing by first intention. After five days the dressings are removed, the unoperated eye cleansed, the tape removed from the socket, and a second dressing applied for another two days. The first dressing should exert a fair amount of pressure over the operated socket to guarantee hæmostasis; the second dressing need not be applied as snugly. At the time the second dressing is changed, the sutures may be removed and the patient placed on hot compresses and cul-de-sac irrigation with warm boric acid to hasten the recession of the postoperative reaction. Under ordinary circumstances the patient may be discharged from the hospital shortly thereafter. The first or temporary prosthesis should not be fitted until this postoperative reaction has receded almost wholly.

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perforate the sclera especially in a soft eye. When the globe has been badly ruptured and is completely collapsed, one must be especially careful not to cut the nerve at the sclera or even to cut the posterior pole of the eyeball instead of the nerve. It is often difficult to identify the nerve itself while working in an orbit swollen with blood or with the edema of a post-traumatic tissue reaction. Old glaucoma with cavernous cupping of the nerve head may permit the perforation of the globe if the nerve is cut too closely at the sclera.

In children, and especially in young children, when an enucleation is indicated, it should be done as soon as possible; also it should in all instances be accompanied by some type of implant into Tenon's capsule. It seems as if an orbit, in such instances, matches the size and the shape of its mate, more closely, than when the enucleation is either delayed, until later years, or when one has failed to place an implant into Tenon's capsule. This point applies especially to children with unilateral anophthalmos. The same is true in cases of gross deformities of the globe with blindness, as in extreme microphthalmos, in macrophthalmos, and with staphylomata, also with phthisis bulbi, and in old perforating injuries, and with atrophy of the globe following old traumatisms, and suppurating conditions of early life, as ophthalmia neonatorum.

It is not uncommon for an enucleation to be followed by a relaxation of the lower lid, with some relaxation ectropion. Some of these cases had had some ectropion with relaxation of the lid prior to the enucleation. The condition is exaggerated, however, following the operation. In such instances sufficient time should be allowed for a full recovery from the surgery of the enucleation before the ectropion is corrected.

EVISCERATION OF THE EYEBALL, AND THE MULES' OPERATION

The two are not synonymous. The former is to be used whenever enucleation is impossible because of the possibility of permitting an intraocular infection into the meningeal space, as this is opened at the time of the neurectomy. A Mules' operation frequently implies the implantation of a ball of some type, gold or bone, into the scleral shell and cannot be done in the presence of infection.

The conjunctiva is cut from the limbus the same as one would do for a simple enucleation. With blunt dissection it is then lifted and detached from the sclera about the limbus well back, so that it can be readily closed over the site of the ablated cornea. The eyeball should be grasped firmly with a fixation forceps and a corneo-scleral section made with a cataract knife, the point of entrance and exit of this to be 2 mm. from the limbus, and should include a third of the circumference of the limbus. The remaining portion of the cornea is then removed with sharp scissors. The entire contents of the scleral shell are then removed with a large curet; *i. e.*, the lens, the iris and the ciliary body, the choroid and the retina. Four hæmostats are placed on the scleral opening, one equidistant from the other, the shell lifted from the orbit and the inside carefully inspected to be sure that no uveal tissue of any type has been retained.

In the case of a simple evisceration two triangular notches are cut from the sclera, at 9 o'clock and 3 o'clock, each about 5 mm. in width, the apex to lie at the middle point of the tendons of the external and internal recti.

Three-0 plain catgut sutures are used to close these notches. Two additional sutures are passed across the scleral opening so that when these are tied the entire scleral opening is closed in a horizontal manner except for a small central area to permit the removal of the packing placed in the scleral shell. Two inches of ½ inch plain gauze packing is placed in the scleral shell with the end protruding. The last two catgut sutures are then tied. The conjunctiva is to be closed with interrupted black silk sutures. The central area through which the packing protrudes is to have two conjunctival sutures inserted also, but these are to be tied in a bow knot so that when the packing is removed, forty-eight hours later, the two sutures can be opened, retied in a square knot, and their ends cut short completing the closure of the conjunctival wound. The packing cannot be removed and discarded before this. Further, if there is considerable discharge it may be necessary to wait an additional forty-eight hours before the packing can be omitted. It is also proper to introduce another piece after the first dressing should the surgeon consider this necessary. Conjunctival sutures usually may be removed on the sixth to the eighth day after an operation. If the central scleral opening should continue to discharge externally through the conjunctiva, it may be wiped out carefully with a 20 per cent trichloracetic acid solution, and this immediately neutralized with a 1 per cent aqueous solution of sodium carbonate. Cases of evisceration, following intra-ocular suppuration may remain open for from two to three weeks following the operation. In such instances it is necessary to repeat the chemical cauterization several times.

The Mules-Dimitry Operation.—As soon as the uveal tract has been thoroughly removed and the notches cut in the sclera as earlier described, four hæmostats are placed upon the edges of the scleral opening. The gold or bone ball must be of such a size that the edges of the scleral opening can be approximated, without gaping, though it is not necessary to permit over-riding of the edges of the opening. In general the ball which is implanted into the sclera will be at least 4 mm. smaller than that which can be implanted into Tenon's capsule. The implant is placed into position with an introducer, and the sclera closed, in its entirety, in a horizontal manner with 3-0 plain catgut. More sutures are necessary here than with a simple evisceration. Special attention must be paid to the central portion of the opening to assure oneself that closure there is adequate. The edges of the overlying conjunctiva are closed with a carefully placed black silk purse string suture; also if the conjunctiva is adequate in amount, the closure may be completed in a vertical line. Closure in a horizontal line would superimpose the second row of sutures above those in the sclera and thus jeopardize the result. Interrupted black silk sutures are best used if a vertical closure is possible. If a purse string suture is used, small bites should be taken in the conjunctiva and the suture is to be placed as close to the edge of the conjunctival opening as is possible. One must be certain, however, that they do not tear through and permit gaping. The postoperative dressing must be binocular for this operation. Before the dressing is applied to the operated eye a small piece of iodoform tape should be placed in the conjunctival sac immediately beneath the palpebral fissure. The dressing should exert a fair amount of pressure upon the operated eye so that late postoperative hæmorrhage cannot occur. The first dressing may be done on the fifth day at which time the packing is to

be removed, the cul-de-sacs flushed with warm saline and a second binocular dressing applied for two additional days. At the time of this second dressing the conjunctival suture or sutures may be removed and a monocular dressing reapplied. This should be worn until the socket is ready for a temporary ocular prosthesis.

O'Connor[1] recommends an exenteration of the ocular contents by a new technique which he feels has very definite advantages. There is a complete absence of a puckered distortion of the globe such as occurs with either the horizontal or the vertical incisions and the artificial eye has a better support and better motility by reason of retention of the cornea, and there is no alteration in the lines of action of any of the recti muscles as the crucial incisions bisect the spaces between their insertions. The steps in his operation are as follows: (1) The conjunctiva is separated from the limbus as is usual. (2) Crucial incisions are made through the cornea and the sclera extending well back of the muscle insertions bisecting the spaces between them. (3) The four flaps outlined are widely separated with mosquito hæmostats and the orbital contents removed *in toto* with gauze and a curet. (4) The optic nerve may be resected if it is desired (the author thinks not necessary). (5) The corneal surfaces are curetted both anteriorly and posteriorly to favor a quick reunion (6) A catgut mattress suture is placed from point to point, so that when tied the four points overlap in close contact. (7) A purse string suture is used in the conjunctiva above the catgut mattress suture in the cornea.

The contraction which is certain and ultimate in the scleral shell after the usual type of evisceration may nullify most of the detailed attention paid to such a technique as outlined by O'Connor unless an implant is utilized.

Burch[2] is even more positive about a preference for eviscerations with scleral implants. He states:[3]

> In general, it is good surgical practice to eviscerate and poor practice to enucleate an uninfected eye, except for intraocular tumor, when a pathological specimen is desired or when an injured eye is too severely damaged. Moreover, there are few contraindications to evisceration with implant, with preservation of the cornea, when the cornea is not diseased, and this is especially true in cases of recent injury.
>
> Technically, the procedure recommended is quite simple. With retrobulbar novocain injection, or under general anesthesia, a circumcorneal incision is made around two-fifths of the cornea, and the conjunctiva reflected, leaving a margin of 5 mm for closure adjacent to the cornea. A small scleral incision is made just anterior to one of the recti muscles, preferably the superior rectus, when possible. With one blade of a straight, blunt Stevens scissors an incision is made between the uvea and sclera, and extended to include about two-fifths of the circumference. The ciliary body is separated with a spatula, an evisceration spoon inserted, and the intraocular contents separated and removed *in toto*. Using a blunt nasal speculum, hemorrhage is thoroughly controlled with compresses soaked in adrenalin, or by the application of a heated probe, mosquito forceps, or the application of a dull cautery to bleeding points. Hemorrhage must be completely controlled. The endothelium on Descemet's membrane is wiped off with a gauze applicator, and the scleral shell is freely irrigated, dried, and swabbed with 1 per cent iodine, neutralized after one minute with 5 per cent cocaine, and again irrigated with saline or boric acid solution. With Carter's introducer, a gold or lead-free glass ball (using one 18 mm. in diameter but sometimes one smaller or even slightly larger) is inserted. Further estimation, for size with easy scleral coaptation, is

[1] O'Connor, Arch. Ophth., 3, 151, February, 1930.
[2] Trans. Am. Ophth., Soc., p. 272, 1941.
[3] Digest of Ophth. and Otolaryngol., p. 821, September, 1940.

made. A 14, 16 or 20 mm. hollow sphere may be preferable, but in removal of the sphere one must avoid inflicting undue trauma and making traction on the optic nerve. The sphere should *not fill the sclera too tightly and thereby* place tension on the sutures. If it is too small it will fail to aid in the control of postoperative oozing within the sclera; nevertheless a slightly too small sphere is preferable to one that is too large. Temporary sutures are placed in the exact ends of the scleral incision for lateral traction by the assistant, in order to secure perfect coaptation of the scleral margins. Fine white silk interrupted sutures, usually about six in number, are mattressed through the sclera. The conjunctiva is closed with black *twisted silk, which is removed after a week* A gauze-cotton compress pad is pressed over the eye with elastoplast and left in place for three days It is again applied after each dressing.

OPTICO-CILIARY NEURECTOMY

This is a procedure occasionally carried out in the instance of a painful eye wherein enucleation cannot be done. In general, it has but few indications. A patient is certainly more comfortable following it. The operation should be done under gas and ether anesthesia whenever possible though it can be done with retrobulbar injections. A small conjunctival incision *is made through the conjunctiva and Tenon's capsule, in the upper outer* quadrant of the superior cul-de-sac, between the upper edge of the external *rectus and the lateral edge of the superior rectus, or through a similar* incision in the inner nasal quadrant between the inner edge of the superior rectus and the upper edge of the internal rectus. While sectioning of the optic nerve itself may be more readily carried out through the nasal quadrant, the complete sectioning of the nerves from the ciliary ganglion is more likely if the neurectomy is done through the superior external quadrant Enucleation scissors are passed through this opening downward and inward until the optic nerve can be felt as a cord. The scissors are then partly withdrawn, opened, advanced, and the optic nerve cut with the other tissues lying within the muscle cone. The scissors are to be immediately withdrawn and the eyeball held against the apex of the orbit, through the closed lid, as a tampon to control the sharp hæmorrhage which results The conjunctival wound need not be closed unless the hæmorrhage does not cease immediately. A binocular pressure dressing must be applied, in such instances, for twenty-four hours to prevent continued bleeding. The orbit and all of the contiguous tissues will become infiltrated with blood unless the hæmorrhage can be well controlled.

DELAYED IMPLANTATIONS INTO TENON'S CAPSULE

In many instances simple enucleations have been done because it was necessary. In such instances the patient must wear a very large ocular prosthesis, the lower lid becomes relaxed, the inferior cul-de-sac becomes increasingly shallow and ptosis of the upper lid will occur. In addition, there is usually considerable atrophy of the retrotarsal tissues of the upper lid.

The appearance of many of these individuals can be improved to a decided degree by a delayed implant into Tenon's capsule. Under general anesthesia, the conjunctiva is opened in a horizontal manner and carefully freed from the underlying fascia, well into the inferior and superior cul-de-sacs and into both canthal angles. The compact mass of Tenon's capsule, in the apex of the orbit, is grasped with a forceps and lifted forward. The capsule can readily be opened with blunt scissors or with a hæmostat,

though occasionally sharp dissection is necessary to start this. This opening can be stretched by carefully spreading the jaws of the scissors or of the hæmostat; at the same time the capsule is lifted, more and more, until it appears approximately the same as a capsule at the time of an uneventful fresh enucleation. The operator must be careful not to tear it. A ring of several fixation forceps is placed on the opening of the capsule and the implant introduced. The size of an implant will be from 2 to 4 mm. smaller than that which would have been possible had an implant been used at the time of the enucleation. The capsule is closed with a purse string catgut suture of 3-0 ten-day chromic, and the conjunctiva closed over it in a horizontal manner with interrupted black silk sutures.

FIG. 101 —*A*, ptosis and ectropion in an old enucleation; *B*, after the implant into Tenon's capsule, and Everbusch ptosis operation, and a Thiersch graft reconstruction of the inferior cul-de-sac.

In many of these cases the inferior cul-de-sac will be so shallow after such a delayed implant that a skin graft reconstruction of the cul-de-sac will be necessary. The same thing applies to the accompanying ptosis in such instances. An Everbusch or Blaskovics ptosis operation will be needed to correct this. Figure 101, *A* and *B*, illustrates such a case, including the delayed implant. (The enucleation had been done as a young child.) In *B*, the patient is wearing her ocular prosthesis. In this case the ptosis operation was done before the cul-de-sac was reconstructed. In general, a reverse order in the stages for the correction of this operation would be somewhat more logical.

CHAPTER V

COMPLETE SYMBLEPHARON. THE CORRECTION OF A GENERALLY CONTRACTED SOCKET

The surgical correction of a generally contracted socket is now to be considered. In the sub-section on Surgery of the Lids, further consideration is given to this subject, in that conjunctival surgery as it applies to incomplete symblepharon and to cul-de-sac restorations, is included under lid surgery.

Complete symblepharon is to be differentiated from a contracted socket on more or less academic principles. Complete symblepharon is undoubtedly a condition in which the epidermal surfaces of the lids are normal but the lids themselves are in blepharophimosis or each in a state of entropion through the loss of their inner conjunctival surface. Because the more or less complete loss of the orbital socket (fundus of the orbit) must accompany the condition, the term "complete symblepharon" is becoming unnecessary.

The basic technique of Morax should be discussed here as he applied it in his discussion of complete symblepharon. Therefore, symblepharon is being considered as a lid and cul-de-sac deformity essentially, and not the consideration of contracted socket. It was thought wise, however, to refer to that section on cul-de-sac and symblepharon corrections in considering any individual problem.

Fig. 102.—*A*, before correction; *B*, during the correction, and *C*, with glass conformer in place awaiting an ocular prosthesis.

PEDICLE FLAP CORRECTION

If the essential soft tissues are still present (conjunctiva and skin) in the upper and the lower lids, a plastic correction can be done utilizing pedicle flaps and even cartilage. Figures 102 and 103 show such an instance wherein the plastic correction was inspired by Morax's technique for total symblepharon (Fig. 104). Figure 105 is another such example. In this case severe injury had occurred to the left eye socket and to the region of the frontal sinuses. Gillies' notes relative to this case[1] are given below.

It is difficult to conceive how the upper lid had become adherent at such a low level. A considerable portion of the lower lid edge was still present, concealed in a pocket beneath the upper lid. An incision was made for raising the upper lid, and

[1] Plastic Surgery of the Face, Oxford Medical Publications, p. 316.

A, *B*, and *C* is such an instance. Further surgery was not desired; the patient, however, wished for a cosmetic correction. A mold of wax was made, to cover the anatomical defect, and externally to conform to the normal side of the face. The external surface of the wax mold was cast first. This completed mold was embedded in sand and an aluminum mold

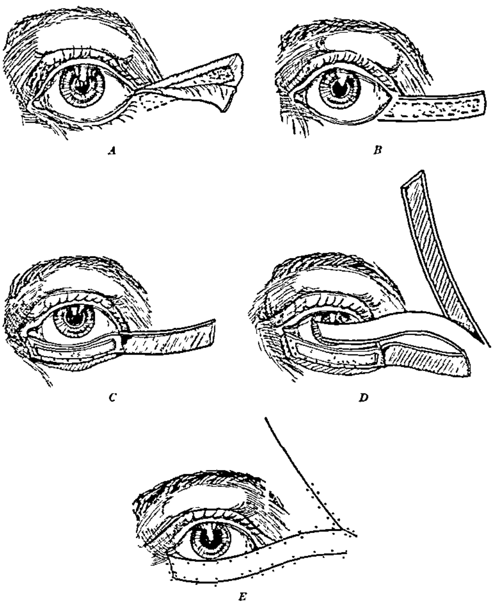
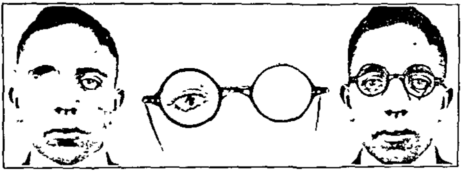


FIG. 106.—Cartilage graft utilization: *A*, and *B*, graft embedded at the outer canthus; *C* and *D*, cartilage in place with pedicle flap to cover the graft, and *E*, completed suture line. (Courtesy of Oxford Medical Publications)

cast from the impression. By painstaking and careful filing, the mold was slowly shaped to fit accurately over the defect. Two short posts were retained at the nasal and temporal ends. The hair lines were built up with very fine copper wire, cut to match the length of the opposite lashes. These lashes were applied with solder of a very fine quality. A prosthesis to

match the natural eye was placed in the posterior shell of the mold, and held in place by small projections similar to the prongs used in mounting jewels. The entire mold was rubbed with fine sandpaper until it was perfectly smooth. It was then painted with oil paints by a competent artist to match absolutely the normal coloring of the face. The last coat was a very thin film of dull shellac, making the mold waterproof. The surgeon must supervise this part of the work carefully so that the purpose of the prosthesis will not be ruined by poor coloring. The work on the mold up to this point may be done by any person who has average skill in the casting of appliances, but the person selected for the painting of the mold should be in every sense of the word an artist. As soon as the appliance is completed it is mounted upon a heavy horn or shell spectacle frame, at the bridge, and on the temple just posterior to the hinge. The two small posts retained on the mold are used for this. The bridge of the frame can be recessed with a square, pit-like, depression to fit the post, and two small screws used to hold it firmly against a small metal plate set in the recess.



A *B* *C*

Fig. 107.—*A*, the original defect; *B*, prosthesis; and *C*, patient before completion of the prosthesis by painting. (Courtesy of P Blakiston's Son & Co.)

The external post is mounted upon the temple in a similar manner. A capable optician may be allowed to carry out this part of the process. As soon as the frame and the appliance is mounted it must fit the patient snugly, covering accurately the defect. The pressure with which the frame fits on the face may be controlled by the curves of the temples passing behind the ears or around the occiput. A plano lens can be placed in the frame over the prosthesis and a correcting lens, if required, over the remaining eye. If the prosthesis has been well and carefully made it should be quite inconspicuous. Utilization of this procedure is invaluable when indicated, and should give great satisfaction to the patient as well as to the ophthalmologist.

The restoration of an orbital socket is one of the most difficult tasks the ophthalmic surgeon has to perform. Many different varieties of the deformity will present themselves for correction. Contracted sockets with inadequate superior and inferior cul-de-sacs will be the most common. Generally contracted sockets filled with scar tissue and unhealthy discharging granulations will be found following traumatic enucleations from battle wounds, industrial accidents, knife fights, and following an enucleation because of severe panophthalmitis. Following an orbital evisceration the operator

will find a socket with stiff adherent scar tissue, painful, conspicuous and wholly incapable of retaining an artificial eye. A mildly contracted socket due to a single band of scar tissue in the superior fornix is the simplest deformity one has to deal with, the cure being the excision of the band of scar tissue and a subsequent suturing of the remainder of the conjunctiva in the cul-de-sac.

Occasionally in reconstructing the lids for some cicatricial defect, and with a socket partly contracted, after the lid incision is made for the reception of graft or a flap, release of the socket contraction is obtained by undermining these incisions. As the tissues remaining are displaced, either inferiorly or superiorly, denuded areas are formed which can be covered by small pedicle flaps. Figure 108 shows the use of a single pedicle flap, which when taken from the temporal region, can be moved into the socket (either directly through a divided external canthus or through a tunneled external canthal commissure). The initial incision made must be at the level of a line drawn through the two canthi. This is well widened by extensive undermining and the upward and downward displacement of the remaining conjunctiva, until sufficient release of the adherent tissues has been obtained to bring the lid margins into easy apposition, and until the socket will retain a mold of dental compound about 20 mm. in thickness, 30 to 35 mm. in length, and 20 to 25 mm. in height, without spreading the palpebral fissure.

As the remaining conjunctiva is undermined it is readily moved from the posterior wall of the fundus of the socket into the inferior and superior fornices, thus leaving a defect presenting immediately at the palpebral fissure for the reception of a graft. Occasionally, in contracted sockets, it seems wiser to utilize the conjunctiva remaining as a covering for the fundus of the orbit and to restore the lining of the lids with the graft instead. This applies whenever, in addition to the contracted socket, there is a tendency to entropion of the lid margin. In such instances the incision must start immediately posterior to the line of lashes and the conjunctiva remaining moved upward and backward, the reverse from that otherwise done. In such cases, where pedicle flap cannot be used, the remaining surgery must be by free skin grafts. The size of this is easily gauged and readily covered by the flap through the external commissure. If the wound is narrow, a simple division of the external canthus with the passage of the pedicle through it will be satisfactory. The base of the pedicle flap should be somewhat below the level of the canthus. If a rather broad flap is necessary it is better to tunnel the external commissure and pass the flap through this dissection. Eight days after the operation the pedicle may be resected. An ordinary tarsorrhaphy at the outer canthus will be sufficient to restore this to its previous normal condition. If the commissure has been tunneled, this latter will not be necessary. As the trimmed and thinned-out head of the pedicle flap is moved into the socket it must be carefully stroked into its proper position with a blunt instrument and then covered with the prepared mold. Frequently no sutures will be necessary, and if they are necessary they can be mattressed through the depths of the cul-de-sac. As soon as the mold is fitted into the socket, over the smooth-lying graft portion of the flap, the lid margins may be closed with a series of temporary intermarginal sutures.

A pedicle flap from the neck also can be used for this same operation without causing the additional facial scar of a temporal graft. When such

a cervical flap is used, the surgeon must be careful to make an accurate pattern of the wound defect to be corrected, because, with the acute angle necessarily present between the course of the pedicle of this flap and the correcting head, difficulties will arise unless the correcting portion be accurately measured. As the flap is being lifted, its correcting head should lie at a 45 degree angle from the central line of the pedicle, facing away from *the line of the body downward and pointing toward the shoulder.* The head of this cervical flap is placed the same as described before.

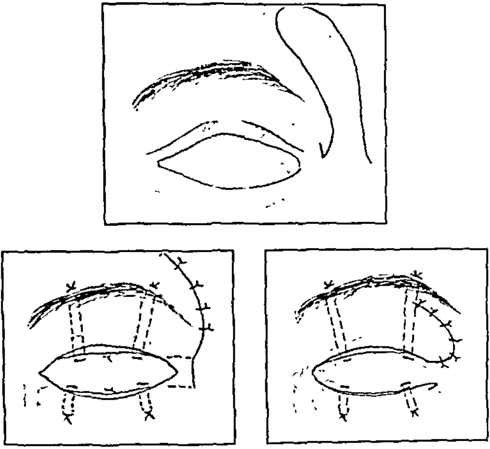


Fig. 108.—Pedicle flap into the fundus of the socket through a divided or a tunneled external canthal commissure.

It is well to repeat a few points in closing this section on orbital repairs and socket reconstructions by means of pedicle flaps. The first is that of the selection of cases. A pedicle flap repair should never be attempted in the absence of conjunctival fornices, that is, the pedicle flap is best adapted for those socket repairs in which *the immediate posterior wall or fundus of the socket alone is absent. The width of the dissection wound to be filled* in will decide whether or not it is necessary to tunnel the external commissure, or incise it for the passage of the pedicle of the flap. The amount of lid repair necessary in the case will assist the surgeon in his choice of the field from which the flap is to be lifted, upper lid, forehead, *temporal portion* of the face, or from the neck, this being the order of flaps to be used depend-

ing upon the degree of contraction. Small defects of the lids may be corrected at the same time the socket is reconstructed. In the dissection for the reception of the flap it is necessary to remove all scar tissue, to displace the elevated conjunctiva toward the lid margins and into the depths of the fornices, even to hold it there by mattress sutures; and to obtain, if possible, exposure of several bony areas for adhesions to develop between the margins of the pedicle flap at its correcting head and the exposed, incised periosteum.

FREE SKIN GRAFT CORRECTION

Verhoeff, Zentmayer, May, Gillies, Wheeler, and others, have presented various modifications of an epidermic graft wrapped over a mold of some sort and placed into the socket after all scar tissue has been excised and released. Some of these surgeons have used gutta-percha molds, others hard rubber and wax molds, and others metal molds. Verhoeff first used a glass sphere. In all of the various methods presented, three points remained constant: the mold was made, selected, or shaped to fit the socket; the graft was cut from the arm or thigh, wrapped over the mold raw surface outermost; and third, it was then sutured or buried into position. Through the work of these eminent men a technique has gradually evolved itself for this operation which has given most satisfactory results in the hands of many other surgeons. Wheeler has almost standardized the operation.

A brief résumé of its salient points is as follows: first, wide excision of all the scar tissue causing the contraction, with conservation of all deep fascia and fat remaining in the socket if it is not impregnated with scar. Careful parallel dissections should then be made along the under surface of the lids to avoid thick and clumsy lids, retaining nothing in the lids proper except the tarsal plates, and the orbicularis muscle.

The author feels that all intact conjunctiva present should be spared. Many operators do not agree with this but resect all conjunctiva present since they believe that the combination of conjunctiva and epithelium is not satisfactory.[1] There seems from personal experience to be no good reason for this contention. Naturally conjunctiva converted by cicatrices to a dry hard nodular mass should be removed.

If the conjunctiva still intact on the posterior surfaces of the lids is thus *dissected it will move from the lids to the fundus of the orbit leaving the* bared raw surfaces of the lids for grafting. The graft will "take" on these regions much better than from the surface of the mass of retained orbital fat and capsule, no matter how healthy this may be. It is for this reason that the recommendation is made to start the dissection on the lid margins —not in the cul-de-sacs, nor over the mass of remaining orbital fat and collapsed capsule.

The dissection must be continued, at the outer commissure behind the skin beyond the plane of the canthus down to the periosteum, in the lower cul-de-sac to the level of the bony orbit, with exposure and incision of the periosteum, and at the inner canthus, a continuation of the incision posterior to the plane of the normal caruncle and to the junction of the suture line

[1] The complaint of dryness in a reconstructed socket (whether of epithelium wholly or of a combination of conjunctiva and epithelium) can be ameliorated decidedly by a small amount of an ointment of lanolin and glycerin with an inert gum as acacia, sufficient to make it smooth, dispensed in a collapsible tube; this should be applied lightly to the back and side surfaces of the artificial eye.

of the nasal spine of the maxilla and the lacrimal bone. In the superior cul-de-sac, the incision is to be made anterior to the orbital fascia, at the level of the rim of the roof of the orbit, and should save, if possible, the levator palpebræ superioris. If the surgeon is in doubt as to the possibility of introducing a mold of satisfactory size, it is quite permissible and wise to incise the outer canthus for any distance necessary. Mattress sutures can be introduced before the mold and graft are inserted; the suture loop being held to the side during this procedure, and after the graft is in place, they may be tied through buttons or small perforated rubber plates. This temporary canthotomy will frequently be the means of a most satisfactory result. The operator should be sure that it is properly closed with adequate sutures, which is a very simple thing to do. If the incision is made too high into the superior cul-de-sac, ptosis will result from sectioning the levator palpebræ and because the ocular prosthesis alone cannot support the lid. In so far as the incision is concerned in the lower lid, "down to the rim of the bony orbit," one does not expect that the reconstructed inferior cul-de-sac will retain this depth. A deep cul-de-sac is maintained, however, by the buried sheet of cicatrix extending from the periosteal rim of the orbit to the most dependent portion of the reconstructed inferior fornix. The dissection inferiorly, therefore, is to go straight down to the orbit, while superiorly it is to go up and backwards; the superior bony rim of the orbit should not be touched.

The mold should be made very carefully. The dental stent (or wax), first sterilized in a solution of mercury bichloride, is washed and broken to an approximate size, while cold and hard. It is then softened to a semi-fluid state in hot sterile water and an approximate amount forced into the dissection. This is to gauge—not the shape of the socket, but the amount of wax necessary in the case. The wax is then removed, again washed and softened in hot water, and molded into a biconvex flat, lens-shaped disk, between the palms of the hands. Its posterior surface, while still soft, is changed to a slightly flattened, even concave curve, and the anterior surface to an increased convexity. The mold is hardened with cold water, again fitted to the dissection for size, trimmed with a sharp scalpel if it is over size, and then permitted to remain in the dissected socket to complete hæmostasis, while the graft is being cut. The lids should just approximate nicely with the mold in the socket. If a canthotomy has been done the mold can be introduced and withdrawn much more readily. The next step is to introduce two mattress sutures, each 4 mm. from the lower lid through the lid margin across the palpebral fissure into the upper lid, again through the lid margin, the point of exit being 3 to 4 mm. above the line of lashes. These are to be tied, later, over tiny pearl buttons, through perforated flat rubber plates, or over tiny rolls of moistened gauze. The loops of these sutures as they cross the palpebral fissure can be moved medially and laterally, while the mold and the graft are being introduced, so that they will not interfere with this part of the operation.

The graft should be cut with a graft razor from the inner aspect of the thigh. The skin of the thigh is first prepared with soap and water, then painted with iodine (or picric acid), and then cleansed with alcohol. Just before the graft is cut, the skin is anointed very lightly with sterile warm melted vaseline. The area from which the graft is to be cut is then held taut between two sterile wooden tongue blades. Figure 109, *A*, shows

such a graft being cut with razor in proper position and with the skin held taut by tongue blades. The operator holds the lower of these two, close to the skin, while an assistant holds the upper. Great assistance can be obtained in cutting the graft in individuals with thick fat thighs, by having the patient's leg elevated from the table; the operator himself sitting upon the edge of the table and the patient's thigh brought down across his thigh, thus flattening all of the tissues of the thigh. If the graft is to be cut from the inner aspect of the right thigh it would be held across his right thigh, the opposite if the graft is being cut from the left. In children and in rather thin individuals, this assistance is not necessary, but in obese individuals it is very much needed. The razor edge is placed against the flattened skin and a very shallow incision made of the required width into the skin. With

FIG 109.—*A*, Thiersch graft being cut with a razor. *B*, graft covered mold being introduced into the prepared socket.

a rapid to and fro motion to the razor, the graft is cut until one has a piece of adequate size. If the razor is dull or the skin not held sufficiently taut, *the razor will pass into and through the dermis.* In such instances one must stop, and even suture this unduly deep cut. If sufficient satisfactory graft has been properly obtained above this, that can be removed with scissors, and utilized, otherwise it is best to smooth out this entire cut and to start afresh. The secret of cutting an Ollier-Thiersch graft lies in a sharp warmed razor, the skin held taut, the razor held delicately and lightly, the rapid to-and-fro movement to the razor as it is being advanced, and the skin and the razor being both lightly covered with melted petrolatum so that the graft will slide up evenly upon the surface of the razor blade. *After the* graft has been cut, the region from which it has been removed should be

bleeding only from the cut capillary buds. This is sponged dry and covered with petrolatum, or paraffin impregnated gauze, an 8 x 8 gauze compress dressing applied and this held in place with a bandage and adhesive.

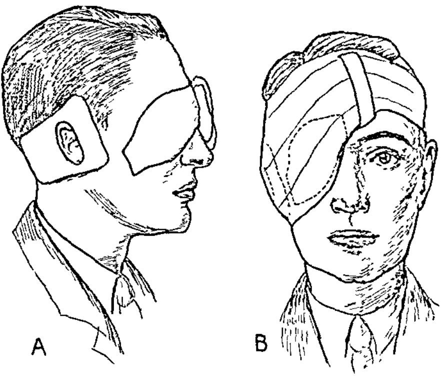


FIG 110 —Ear pads and roller bandage for pressure dressing

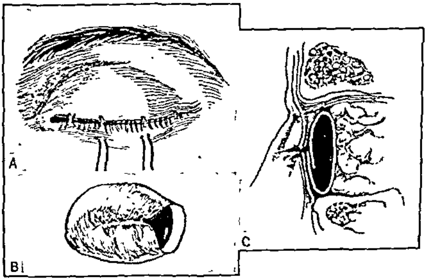


FIG. 111.—*A*, mattress suture for closing the palpebral fissure, *B*, graft-wrapped mold; *C*, schematic side view to show graft and mold in position

The mold must be completely covered and the graft so arranged that the overlapping of the graft presents at the palpebral fissure, making easy the

subsequent removal of the mold. The mold must be placed without disturbing or wrinkling the graft wrapped upon the mold, and with an accurate contact between the surfaces of the socket and all portions of the graft, Figure 109, *B*, shows this graft-wrapped mold being placed into the socket. The sutures mentioned are tied giving a temporary complete tarsorrhaphy (Fig. 111, *A*, *B*, and *C*). Oiled silk is placed over the palpebral fissure, a sea sponge upon this, and a pressure bandage applied which will not creep. This dressing should not be disturbed before the eighth day, and both eyes must be included in the figure of 8 bandage. The proper postoperative treatment of the patient is the renewal of the dressings, the retention of the mold for two weeks, and thereafter the fitting of a matched ocular prosthesis for permanent wear. (Fig. 112, *A*, and *A'*, *B* and *B'*.)

FIG 112 —*A* and *B*, before, and *A'* and *B'*, after the reconstruction of generally contracted sockets

Recently, Pfeiffer[1] presented ear pads cut from ½ inch thick white felt designed to protect the auricle and to distribute the pressure evenly over the surrounding surface. According to Pfeiffer's technique, before the dressing is applied (see Fig. 110):

An intermarginal silk suture is first placed in position to insure complete closure of the interpalpebral fissure. A flat 2-inch-square gauze sponge anointed with sterile vaseline is placed on the skin of the lids after the upper lid is carefully pulled down. In plastic operations rubberized tissue anointed with vaseline is used on the skin in place of gauze. Then loose gauze sponges are piled on to raise the level above that of the brow. Adhesive plaster strips 1 inch wide and 6 inches long, are then placed across the gauze at an angle of 45 degrees with the mid-plane of the face. The first is stretched across to anchor the gauze. The second is placed temporally in a curved manner to tuck in the gauze and hold it securely. The third is placed on the nasal side to hold in the gauze here. Two or three more tapes are lastly placed

[1] Am. Jour. Ophth., Ser. 3, 23, 1156, 1940.

socket incorporated in the cast on its front surface. A stout piece of malleable German-silver wire, with squared ends, is inserted into the socket on the dental appliance and into the socket of the gutta-percha mold. A sufficient curve is then given to this wire so that the mold rests immediately over the palpebral fissure of the contracted socket. The degree of backward pressure desired is obtained by further curving this wire. The pressure should be sufficient to indent constantly, but should not be so great as to cause ulceration. From day to day this can be increased and in a short time from ten days to two weeks it will lie between the lids well within the superficial portion of the socket. Further necessary adjustments are made

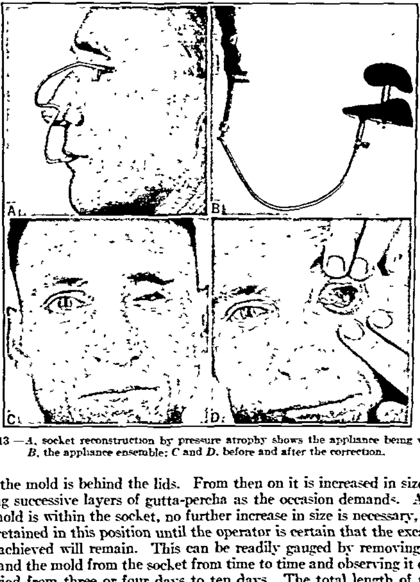


FIG. 113.—*A*, socket reconstruction by pressure atrophy shows the appliance being worn *B*, the appliance ensemble; *C* and *D*, before and after the correction.

until the mold is behind the lids. From then on it is increased in size by adding successive layers of gutta-percha as the occasion demands. After the mold is within the socket, no further increase in size is necessary, and it is retained in this position until the operator is certain that the excavation achieved will remain. This can be readily gauged by removing the wire and the mold from the socket from time to time and observing it over a period from three or four days to ten days. The total length of time necessary will be somewhat less than three months. Figure 113 illustrates such a case with the appliance being worn and the completed socket obtained. The upper right of the four pictures is the ensemble of a similar mold used for another case wherein the total plate was needed for thinning

out a thick scar impregnated immobile upper lid. Figure 114, *A*, *B*, and *C*, illustrates a similar case which resulted from a mine accident; the socket was remolded by pressure atrophy, the lower lid was formed from an epithelial-lined pocket made upon the face and by a free skin graft into the upper lid from the skin of the left upper lid. The epithelial-lined pocket on the face can be seen rather readily in *A*, in that it has a plate of dental stent in this pocket awaiting its subsequent elevation for the reformation of the lower lid; *B* has a mold of dental stent within the reconstructed socket while the patient is waiting for his glass prosthesis. Figure 114, *C* is a drawing to show the formation of this pocket and the manner in which it was lifted from the face as a pedicle flap with the skin of the face on its anterior surface and with its correcting head epithelialized upon its posterior surface.

FIG. 114.—*A*, case with pressure appliance being worn, epithelial lined pocket on cheek for the later reconstruction of the lower lid; *B*, completed case with a mold in the socket awaiting a prosthesis; *C*, sketch to illustrate the grafts into the upper and lower lids

In the making of these pressure plates, two rules must be observed, the necessity of having thick, smooth edges, and care in making the first model. The stent should be very soft, and while it is in this condition, mold it directly over the tissues which are to receive the subsequent pressure. Small probes in the hands of an assistant can hold the tissues fixed Thin strips of adhesive may also be used, and the author used temporary sutures in one case. After the core of the rough mold has hardened, the model can be completed with the aid of an alcohol lamp. By passing the mold momentarily through the flame to soften the exterior, and into a basin of iced water to harden the exterior, its edges and surfaces may be made entirely smooth. A small flat instrument which can be heated is used as a modeling spatula. A stout scalpel will be necessary as well. It is best to have a dentist cast the permanent plate and to rebuild these plates, when additions to them have become necessary.

The orbital reconstructions which are done following complete orbital exenterations are oftentimes a difficult problem. The exigencies, which cover the varying degrees in the defect for correction, have been mentioned. Many of these will have defects of the lids accompanying the contracted socket. They are, therefore, considered under cul-de-sac repairs. Figure

115 is the completion photograph following a socket reconstruction in a case wherein an orbital exenteration had been done several years earlier. In this patient the lid margins and the line of lashes were retained. The end-result is fairly satisfactory, but the lids have no motion whatsoever. This unfortunately cannot be corrected. In such instances, it is wise to narrow the palpebral fissure as much as is possible by an angle tarsorrhaphy at the outer canthus according to the technique of Wheeler. The end-result will be more satisfactory to patient as well as to operator. A Wheeler tarsorrhaphy may be used to complete these cases.

FIG 115 —Completed case after the repair of an exenterated socket.

The removal of the stent must be done at times in children under general anesthesia. On the tenth to the twelfth day after the operation this should be taken out, the socket carefully syringed and cleansed of all exfoliated epidermis, and a proper sized silver conformer reintroduced. The perforation in the center of this permits adequate cleansing, and its shape and size prevent contraction. Granulations occasionally occur at this time in the depths of the socket. These should be snipped off, and their base cauterized with 2 per cent silver. As soon as the socket is clean and the operative reaction has disappeared wholly, a permanent eye may be ordered; either a shell eye or a reformed eye depending upon the amount of tissue which remains within the fundus of the orbit.

Frequent cleansing is necessary in all epithelial lined sockets to prevent the accumulation of desquamatous and exfoliated débris. If these are allowed to collect an unpleasant odor will develop and irritation occur to the lid margins.

The reconstruction of a completely lost socket following exenteration of the orbit, wherein the bony cavity was previously lined with Thiersch grafts and the remaining portions of the lids placed within the orbit as has been previously described may occasionally need a slightly different procedure. Goldstein[1] has described a technique for this. After complete healing of the eviscerated socket, the adherent lids were freed, and Thiersch grafts are placed on the denuded areas on the bone and on the back of the lids. The grafts can be held in position by a gauze packing. Three weeks later the lids themselves are divided on their margins from the inner to the

[1] Arch. Ophth, vol 16, September, 1936.

outer canthi, the dissection being carried almost to the bony margins of the orbit. This horizontal division of the lids for their entire length gives the effect of two uppers and two lowers. Into the sulcus formed by separating the two lids a thin mold is placed, covered by a Thiersch graft, and kept in position by temporary sutures holding the two parts of the divided lid together. Each upper and lower lid were similarly treated. Immobility may be obtained by placing packing in the orbit and a compress dressing over the lids. The procedure permits the formation of two sulci in which the artificial eye rests. The hair lines may be reconstructed according to Wheeler's technique (see section on Lids). (The utilization of this principle emphasizes the necessity for retaining the lashes if it is at all possible in these cases wherein exenteration of the orbit is demanded.)

In these cases of generally contracted sockets, so many other accompanying defects are frequently present, as well, that the operator must exert much ingenuity to achieve satisfactory results in all of them.

CHAPTER VI

THE PHYSIOLOGY OF STRABISMUS. SURGERY OF THE OCULAR MUSCLES. INSTRUMENTS. ANESTHESIA. SURGICAL TECHNIQUE

THE DEVELOPMENT OF SQUINT AND CERTAIN NON-SURGICAL PRINCIPLES CONNECTED WITH ITS CORRECTION

The term fusion is usually taken to mean a cerebral function with a sharply demarcated cortical center, similar to that ascribed to convergence, to speech, and so forth. Phylogenetically single binocular vision is not a gift ascribed only to the anthropoids. In all mammals the relative number of uncrossed fibers is closely proportional to the degree of frontality of the two eyes. It is about one-eighth to one-sixteenth of the whole in the horse, one-fifth in the rat and in the common opossum, one-fourth in the dog, one-third in the cat; reaches a maximum of 50 per cent in the higher primates and a low minimum in laterally-eyed forms, but even the rabbit has a high percentage of uncrossed fibers. This relationship of crossed to uncrossed fibers is the law of Newton-Müller-Gudden and holds good only for the mammals. Outside of that class there is no case of a partial decussation of any degree whatsoever. Quoting Walls' *The Vertebrate Eye*:[1]

> The supposed value of partial decussation is not connected with the necessity for cerebral visual lateralization. A few have thought that partial decussation arose as a device for preserving, in animals with frontal or partly frontal eyes, the original status in which the left brain saw everything that was to the right of the animal, and the right brain kept watch on the left—the situation which is obtained in a lamprey, for example, where there is total decussation and no binocular fields at all. But this naive view presupposes that the ancient invention of total decussation was somehow of vital importance in the first place, and still where it rides roughshod over the fact that Gudden's Law is inapplicable in lower groups despite the presence in them of species with even total frontality, as some deep sea fishes, owls, and dynamically chameleons.

Too often ophthalmologists have considered the area centralis and the presence of a fovea as basic for the exquisite central visual acuity of the primate made possible by the minimum separable function of the macular cones. Briefly the fovea, at its central depression, is designed deliberately by nature for magnification of the retinal image which strikes the vitreo-retinal boundary and then becomes magnified through the refractive index of the retinal tissue. Thus when it reaches the level of the visual cells the magnification of the image may be as great as 30 per cent. The fovea is remarkably well developed in avian life. This area becomes a pure cone island in a duplex sea of unmodified retina. It is equally significant that some pure cone animals with extremely good vision, the ground squirrels for instance, have never produced a fovea simply because their entire retina is built as well for acuity as is the macula of man.

Actually semidecussation of the visual fibers seems to be the result of, and the necessity for, bilateral, unilateral, and contralateral representation

[1] Cranbrook Institute of Science, Bulletin No. 19, 1942.

of the visual fibers to permit the concomitant movement of the eye—an essential attribute of single binocular vision. These concomitant movements, both voluntary as well as reflex, demand semidecussation of the fibers. Uniocular and the monocular perimetric field of vision is protected and subserved as satisfactorily in mammalian life with total crossing of the optic nerve fibers.

With this anatomical fact as a basis it is much more logical to consider the development of single binocular vision as one of a perfectly conditioned reflex. The conditioning of this reflex which gives single binocular vision depends upon birth situations, and sensory and motor attributes. Any one or two of these may be impaired. The result is shown in the various types of strabismus which can develop, and which are seen. Single binocular vision is a reversible process. It can be upset, lost, and regained. Actually the presence of diplopia is the proof of a preexisting single binocular vision.

In addition to the semidecussation of the visual fibers there are other anatomical structures which must be considered in the development of a conditioned reflex such as we are now considering single binocular vision to be. These include the neck muscles, the otoliths, the semicircular canals, proprioceptive reflexes and impulses from the eye muscles themselves, fixation reflexes from the occipital cortex, the accommodation reflex, and last, sources of tonus either not yet discovered or not adequately explained

Birth and the developmental situation is the next subdivision for discussion. At birth the eye shows a lack of foveal development, and almost complete absence of accommodation. The neuro-anatomy is still immature. Both phases of labyrinthian nystagmus are either absent or very slightly developed, and all postural reflexes are masked by cortical inhibition. The aimless movements of the infant demonstrate this very clearly At two weeks of life there are some vergence responses to an electric light At six weeks of life the vergences of fixation and refixation are often of good range but last for only a very few seconds. At eight weeks of life the eyes will follow the movement of the hand with some prolonged regard of objects smaller than the hand. The vergences are now good At sixteen weeks of life the infant will hold up his head, will inspect his own hand, and will reach with his hand toward an object. His vision is approximately 6/70. At six months of life a prism base up will usually be resented Binocularity of vision, however, is still very easily surrendered. At nine months of life the child's vision is about 6/70. From twelve to fourteen months of life the body follows the head and eyes. The child attempts an erect posture. The retinal reflexes are still capable of rapid extension. The infant should point to his eyes, to his mouth, to his ears, and so forth At two years of life the visual acuity should be at least 6/12. Extreme vergences are maintained for minutes at a time. Extreme abduction is sustained for only a second or more. The reflexes are more refined but are still easily extinguished. At three years of life the vision should be at least 6/9, but it suffers easily and greatly from disuse. At four years of life the vision should be 6/6. The reflexes are grounded to a great extent. Disuse, however, causes rapid deterioration but not extinction. Re-use results in rapid recovery of any loss sustained at or after this age. At five years of life the reflexes are assuming an unconditioned fixity but are still capable of some loss, for the period of flux does not end till the sixth year of life. At this time the reflexes should be unconditionally fixed.

The next subdivision in this theory of binocularity as a conditioned reflex is the mention of the sensory obstacles and the sensory situations responsible for a part of the life cycle of strabismus.

Disturbances in illumination as seen in congenital cataracts (we see a similar situation developing and causing miners' nystagmus in adult life), the threshold of foveal vision especially in the light adapted eye, errors of refraction, anisomeropia, opacities in the media, anatomical and developmental defects of the retina and the optic nerve. These retinal neural obstacles can well be the result of birth hæmorrhages. Retinal hæmorrhages in the newborn are a much more common condition than is universally considered, present in from 40 to 60 per cent of all newborn children. Defective proprioceptive senses or sensations are seen in babies, and the sensory heteroception which arises as a result of a pure motor obstacle. Such a situation could quite likely be the underlying cause for heterophoria. The accommodation convergence relationship here in a developing infant is a definite sensory stimulus for binocularity or a sensory obstacle resulting in squint. When this accommodation convergence relationship is upset either because of high hyperopia or differences in hyperopia between the two eyes, the patient either accommodates all the way, sees clearly, and has diplopia, or he develops squint; or he contents himself with blurred vision and has no diplopia. The infant resents diplopia so if he sees two objects he immediately starts sensory inhibition, thereby developing strabismus and simultaneously losing vision from suppression.

The motor defects or obstacles include such situations as anatomical dissociation, and defects arising from birth injuries to the globe, faulty insertions of the ocular muscles, fibrosis of an ocular muscle, the non-development of an ocular muscle as a result of damage to the periaxial mesodermal masses, oxycephaly, minor paralyses of ocular muscles with spontaneous recovery, and transient inflammatory changes in infants. This is a condition rather commonly disregarded, in spite of the fact that every ophthalmologist is aware of the high degree of astigmatism which can develop as a result of minor corneal inflammatory changes during the very early years of life. The ocular motor fibroses may be the result of aplasia of an ocular motor nucleus, organization of blood from a birth injury as seen in non-ocular torticollis, and contracture of the antagonist of a muscle imperfectly exercised.

Central nervous system pathology may also be responsible for motor defects—such conditions as: involving the nuclei, the pathways, the trunk, even the supra-nuclear cortical regions, and neopallium at the second frontal gyrus. (Probably all squints with a vertical component are based upon a strong motor obstacle.) Other more or less intangible central nervous system obstacles include the hyperexcitability of the central nervous system as seen in teething, the toxins from measles, and other allied diseases of childhood, central nervous system indocility and pathological degrees of difficulty in the development of any degree or type of coördination. Hypoexcitability of the central nervous system is also a probable factor. This is seen so commonly in feebleminded and mentally deficient children. In these, disturbances of single binocular vision are a very common finding.

Considering these probabilities just discussed we must now answer the following disturbances of the ocular motor apparatus. The first, amblyopia

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without squint; and, second, its homologue, bilateral normal single vision without stereoscopic vision. The third, strabismus of all types, accommodative, non-accommodative, strabismus with a vertical component, and alternating strabismus. The fourth is congenital nystagmus in situations wherein the pathology does not lie in the neuroretinal structures as seen with albinism.

Before presenting the life cycle of these various types of squints *some of* the fusion fallacies which are quite manifest can be noted here.

In so-called accommodative squint (and this is a true pathological condition, though without a surgical side to its therapy), the vision is not as badly impaired as in non-accommodative squint. Abnormal retinal correspondence (which exists when the difference between the objective and the subjective angles is at least five degrees) is always less. The eyes are straight with glasses on in over 90 per cent of the cases, and a weak binocularity *is seldom if ever improved.* Also *an inadequate degree of this is* always present. Surgery, when carried out in these cases, usually results in a secondary condition far worse than that present primarily.

Some of the fusion fallacies which appear in non-accommodative squint follow. Few, if any, of these cases are relieved by glasses, though many are improved by even 25 per cent in the amount of the squint present. Seventy-five per cent of these cases must have surgery. The greater the degree of amblyopia the greater the necessity for surgery. The higher the refractive error the less necessary is surgery going to be in many instances The *squint, however, has its highest incidence in hyperopia of the moderate* degrees of severity. Hyperopia below 1.5 diopters, and above 4.5 diopters is a rare finding; furthermore, convergent squint and myopia, together, are not too uncommon. Abnormal retinal correspondence is present in almost 100 per cent of the cases. As an average, the objective angle is many times greater than is the subjective angle of the squint. The so-called fusion amplitude is even lower in degree than in the accommodative type Alternation develops in these children from monocular occlusion. Orthoptics is of no value whatsoever if abnormal retinal correspondence is present or if *subnormal vision is present and cannot be corrected.* Fusion improves spontaneously after surgery, frequently to a marked degree. Orthoptics are *not uncommonly contraindicated in these cases, and when used may* even make the patient worse in his degree and type of squint.

The following charts are plotted as a balance of sensory and motor obstacles as if one were illustrating, by diagram, the resultants of forces.

In the presentation of these charts I am indebted to Adler[1] and to Chavasse[2] for their stimulating discussions in the development of squint and the physiology basically at fault in the ocular life cycle of the squinter.

Figure 116 illustrates the factors connected with the development of ordinary non-accommodative concomitant squint and of possibilities which *can occur as offshoots.* Chart 2 illustrates amblyopia with but minimum squint, also the opposite as well, the accommodative form of squint which *responds to the correction of the accommodation convergent relationships.* Chart 3 with its high degree of motor obstacles of various types should illustrate the more unusual *and bizarre forms of the ocular motor disturbances.*

[1] Adler, F. H: Personal communication, 1943.
[2] Chavasse: Worth's Squint, 7th ed, Philadelphia, The Blakiston Company, 1939.

Non-surgical Treatment.—The non-surgical treatment of squint is properly presented here. In considering this there are two major factors of outstanding importance: the first is the suppression of the macular images, the second is the matter of abnormal retinal correspondence or anomalous projection, which is the term used by Verhoeff, and which is to be universally adopted as most in accordance with the conception connected with disparate retinal projection.

Suppression of macular images is an innate function of the visual mechanism and can always be done normally without any difficulty. In squint the faculty of suppression is developed simply by the constant use of suppression.[1] When a macular image is suppressed amblyopia develops thereafter. It is to be noted however, that suppression can and does exist without amblyopia. The alternate suppression of so-called alternating strabismus without amblyopia is very well known. So also is the suppression without amblyopia as a common finding in alternating diverging strabismus and in some of the lesser degrees of monocular divergent strabismus.

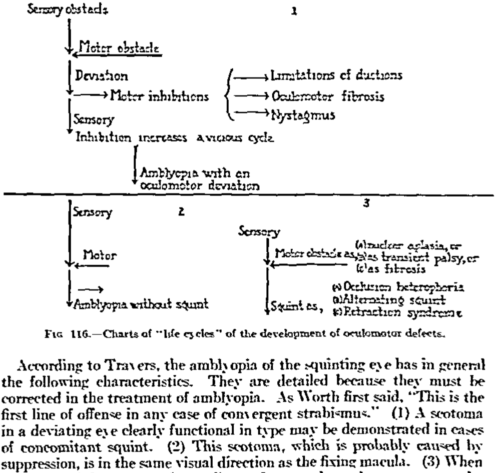

FIG. 116.—Charts of "life cycles" of the development of oculomotor defects.

According to Travers, the amblyopia of the squinting eye has in general the following characteristics. They are detailed because they must be corrected in the treatment of amblyopia. As Worth first said, "This is the first line of offense in any case of convergent strabismus." (1) A scotoma in a deviating eye clearly functional in type may be demonstrated in cases of concomitant squint. (2) This scotoma, which is probably caused by suppression, is in the same visual direction as the fixing macula. (3) When the vision of the two eyes is equally good, or nearly so the scotoma may be demonstrated in whatever eye happens to be squinting. It ceases to exist

[1] In this discussion of the non-surgical treatment of concomitant strabismus the author has drawn freely upon the *Gifford Edmonds Prize in Ophthalmology for 1937* by T. Ab. Travers as printed and published for *The British Journal of Ophthalmology*. Indebtedness is acknowledged herewith to this work.

when the eye holds the attention. It is a rather clear demonstration of its functional characteristics. (4) A second scotoma over the squinting macula may be demonstrated in some cases. It is possibly an early stage in the development of amblyopia following suppression. (5) The first scotoma mentioned may vary in size from about 2 degrees to about 30 degrees in diameter. In many cases it involves the macula. Evans has shown that these may be central, paracentral, and cæcocentral in character.

In general, from the time that occlusion is begun until the effort is made to straighten the equal, and now freely alternating eyes with a trial by glasses or through surgery, one eye should *never be unoccluded except for testing*. (See Fig. 117.) Any occlusion short of total occlusion is permissible *only in certain rather uncommon cases of accommodational convergence* as (*a*) the eyes are straight with glasses, or (*b*) the primary deviation

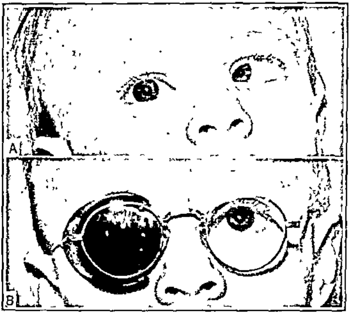

FIG. 117.—Monocular squint, O.S. with torticollis; with a satisfactory occluder being worn. Occluders which are attached to the lens by a suction cup are not satisfactory.

without glasses is pronounced. A third is also occasionally seen, that is deviation which is present only with glasses. It is not only a situation connected with myopia, but is also, not uncommonly, seen in high hyperopia and hyperopic astigmatism, especially when of a marked difference in degree between the two eyes. By such occlusion the usually squinting eye can be trained to mastery, and glasses can either be dispensed with or made weaker without precipitating the squint. In young children, occlusion is so important that one or the other eye should be effectively occluded by strapping on a patch even when the glasses are removed for the night. It is important to impress upon the parents or the nurse of the patient that occlusion continues until the formerly strabotic eye continues to fix, and that eye behind the occluder does not squint when the occluder is removed. If this continues for more than a few hours, either with or without glasses, if they are used, it is a simple matter to transfer the occluder to the formerly

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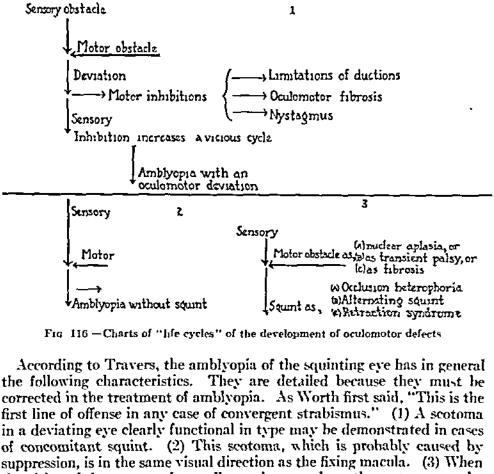

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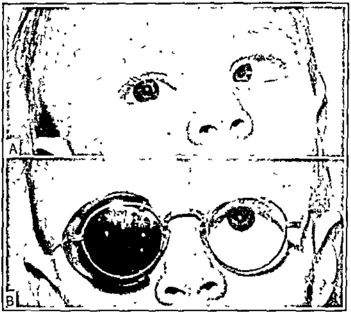

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strabotic eye and thus develop the essential alternation which is the basis for subsequent treatment.

Abnormal retinal correspondence or anomalous projection is developed by the patient maintaining a constantly high level of attention on the two unlike macular scenes so as to keep one separated from the other and to project each approximately to its true position. The direct means of attacking anomalous projection is that of centering attention on the conflicting fields. Conversely, the direct means of attacking amblyopia is that of centering attention on the previously neglected direction. It is rather interesting because the divided attention between the two conflicting fields is influential in its genesis. Anomalous projection of recent origin will show many interesting vagaries and asymmetries, for instance a pair of unlike pictures will be perceived as widely separated when placed in front of each eye, while fusible pictures may not only be fused but even seen stereoscopically. Anomalous projection of long duration, however, shows by the stereoscope that a high attention level has spread to a great distance from the macula. In general, and this has been borne out clinically, too much work with abnormal correspondence may result in settling the abnormal relationship more firmly in the patient's mind. It encourages an analytical, attentive mental attitude, whereas normal correspondence is best regained by relaxing mental vigilance to give the innate nervous mechanism a chance. This is undoubtedly the reason why there is so much spontaneous projection and improvement after early surgery as Gibson[1] said, "A demonstration of orthoptics in its truest sense." The readjustment of the anterior posterior axis of the formerly strabotic eye is an ideal means of breaking up the former disparate projection.

Actually, one macula corresponds with some eccentric point in the opposite eye, and as this matter of corresponding retinal points is a reversible process, a new false macula develops about itself a new system of correspondence. It is as if the whole system of retinal correspondence had been shifted through a varying number of degrees laterally, also perhaps vertically.

There are two types of abnormal retinal correspondence. Their differentiation is not purely an academic situation. They are differentiated one from the other by their angles of anomaly.

In the harmonious abnormal retinal correspondence the angle of anomaly and the angle of squint are equal. This type of correspondence would appear to indicate a harmonious working of the two eyes, in that the impulses from the incident light have the same visual direction as in the normal eye, and they probably reinforce the impulses from the normal eye and so give an inferior type of binocular vision.

In the unharmonious abnormal retinal correspondence the angle of anomaly and the angle of squint are unequal. Actually, the angle of anomaly is less than the angle of squint, except after surgery. In this it is clear that the squinting eye cannot by its impulses reinforce those from the normal, as the impulses in the squinting eye in this condition originate from light having a different visual direction.

Abnormal retinal correspondence is not the same as a false macula. In this condition, the vision of the squinting eye has become so defective that the central visual acuity has fallen below that of the peripheral retina. It

[1] Gibson, Glen: Personal communication, 1941.

is likely that all cases of false macula also have unharmonious abnormal retinal correspondence, but the two conditions are not dependent on each other. A high degree of amblyopia is present with a false macula. Amblyopia may exist with or without abnormal correspondence. Abnormal retinal correspondence is not a fixed and definite relationship. The angle of anomaly will differ in degree from slightly to greatly from day to day, and frequently vary in measurements as made by different methods. The percentage of the condition is probably about 70 per cent of all cases of concomitant squint. Some writers find it as low as 50 and even 30 per cent. It is difficult to diagnose normal correspondence in the presence of considerable amblyopia. It is certain that one will find the largest number of squinters with severe amblyopia to have an abnormal retinal correspondence.

The diagnosis of the condition of correspondence is the first essential in the treatment of the fault. According to Travers the important factors are as follows: (*a*) degree of amblyopia, that is the vision of the true macula; (*b*) degree and type of abnormal retinal correspondence (in the worse type of harmonious correspondence, covering the straight eye does not lessen the angle of squint); (*c*) acuity of vision in eccentric fixation, (*d*) the degree of unharmonious correspondent angle of anomaly; and (*e*) examination for survival of normal sensory correspondence as seen by the after-image test, reflecting stereoscope, bar reading, the synoptophore and so forth.

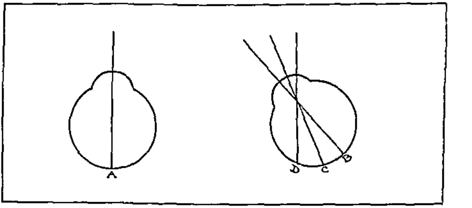

Fig. 118

In harmonious abnormal retinal correspondence the angle of anomaly and angle of squint are equal. In Figure 118 the point *A* from the left eye would correspond with point *D* from the right eye. This type of correspondence would appear to indicate a harmonious working of the two eyes—in that the impulses from *D*, which resulted from incident light having the same visual direction as that falling on *A*, could presumably reinforce the impulse from *A* and so give an inferior type of binocular vision.

In unharmonious abnormal retinal correspondence the angle of anomaly and angle of squint are unequal—actually the angle of anomaly is always less than the angle of squint. In Figure 118 the point *A*, *OS*, corresponds with, say, the point *C*, *OD*. It is clear that in this case there could be no

form of reinforcement of the impulses from A by those of its corresponding point C, as the latter originate from light having a different visual direction.

To diagnose an abnormal retinal correspondence with the synoptophore one should proceed as follows:

The patient is seated looking into the instrument and two "simultaneous perception" slides—such as the butterfly and the net (Fig. 119)—are placed in the lanterns.

The instrument is adjusted so that there is no movement of the eyes when the patient looks first to the center of the net and then at the butterfly. *The instrument is now set at the angle of squint*—because the image of the butterfly will be falling on one macula and that of the net on the other—as in Figure 119.

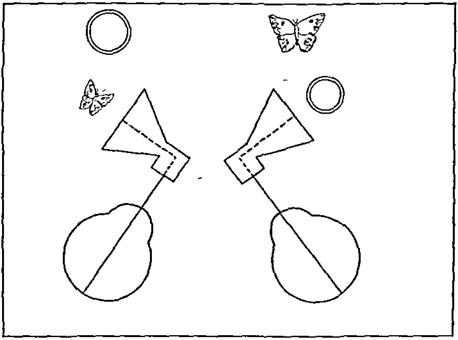

FIG. 119

Now if the retinal correspondence is normal the patient will see the two pictures superimposed—*i. e.*, the butterfly in the net. Conversely, if the butterfly appears to be outside the net, retinal correspondence must be abnormal.

There are very few difficulties encountered in making this simple investigation. If the child cannot understand the questions asked, a little tuition at home by the mother will usually enable one to extract the desired information.

1. Maintain constant total occlusion of one eye except during orthoptic exercise, so that the need for independent projection disappears.

2 It is not necessary to measure the angle of anomaly except in special cases, when one should indicate by one's manner that the results are unimportant.

3. During treatment the patient must watch the pictures constantly, but for most exercises he will do best if his attention is distracted by stories, conversation about home affairs, discussion of some detail in the

appearance of the pictures, or any subject other than the relative position of the two pictures before him. *To maintain the right state of attentive inattention is the most difficult and most important feature of the orthoptist's work.* Each patient will require different methods of approach, and will respond best to different combinations of the methods outlined in 4 and 5.

4. Normal correspondence may be encouraged *most readily by inserting* fusion pictures, preferable with fusion check and some stereoscopic element at the angle of squint, locking the tubes and (*a*) shaking them in front of the patient in a quick jerky manner, (*b*) rapidly alternating the lights behind the pictures, (*c*) making the patient shut his eyes for a moment and then look again. Once a single image is perceived and held, attention to check marks and stereopsis is encouraged. When fusion can be maintained *in the primary position, adduction (in convergent squints) or abduction* (divergents) should be developed, to encourage fusion reflex movements without risk of falling back on abnormal correspondence.

5. Normal correspondence is not firmly established until simultaneous macular perception slides are seen together at the true angle of squint. Methods of achieving this are:

(*a*) Using (for example) a lion and cage set of slides, the patient fixes *the lion while the cage is swept up steadily from outside the angle* It is important that fixation should be steady, the story being that "the lion will get frightened if he knows the cage is coming, so we must pretend not to know it's there." The cage tube should be carried on a little past the angle of squint, and then moved backwards and forwards for a while across the lion. *The subsequent return movement of the tube to the outward* position must be done quickly while talking so that the reverse approach of the cage is disregarded. If the patient takes an interest in the return movement, or if he fails to maintain steady fixation on the lion, this exercise must be abandoned.

(*b*) The patient maintains fixation on the lion, while the cage tube is moved backwards and forwards across the angle

(*c*) *The tubes are locked together at the angle and shaken.*

(*d*) If the patient is intelligent, one may carry on a modified form of "chasing." First it is demonstrated to him that at the true angle the pictures are both seen at once more clearly than in any other position (although they appear to be separated in space). The orthoptist then moves one of the tubes, and the patient moves the other so as to bring the pictures again to the clearest position. This exercise must, of course, be *abandoned if the patient attempts to approximate the pictures at the* "false" angle.

Much has been written on the *rôle of orthoptic exercise in its relationship* to squint. In the final analysis the place for muscle exercising, duction training and so forth, has its greatest field in the treatment of a phoria and, second, in the postoperative treatment of residuals as residual amblyopia, newly developed phorias, and the vestiges of correspondence disturbances. If this is a fact, then, first the place for duction training and other similar exercises is of greatest value in clearing up a certain residual *postoperative phoria after surgery. A squint which continues after the* correction of abnormal correspondence and after the cure of the amblyopia has in its life-cycle development such a *strong motor attribute that surgery*

is going to be necessary. In general 75 per cent of monocular convergent strabismus and 90 per cent of divergent squint, both monocular as well as divergent alternating, is to be corrected by surgery, but the surgery is not to be carried out until the time for it is correct. If a child is so old that occlusion produces little or no further improvement in the amblyopia other than that initial jump-up in acuity after the first days of enforced concentration, then any occlusion will have equally little effect on the ingrained facultative macular inhibitions and the secondary retinal positive correspondence. Similarly in congenital alternating squints the alternating macular inhibitions and the secondary retinal positive correspondence may also defy all treatment except operative treatment completed sufficiently early for the normal combined use and correspondence to be developed thereafter.

SURGICAL PRINCIPLES CONNECTED WITH THE OCULAR MUSCLES

In discussing the surgery of the ocular muscles it is inevitable that one must also carry over into the consideration "certain physiological principles which are inherent to and connected with the extra-ocular muscle," as Peter states. It must be assumed that the reader understands their primary and secondary actions, as well as their surgical anatomy, and that he is aware of their synergistic as well as antagonistic actions, as a detailed consideration of these physiological principles is impossible here. This

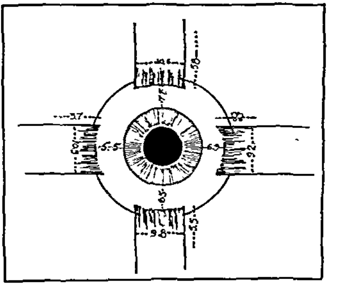

FIG. 120.—Diagrammatic measurements of the insertions, tendon lengths, widths and distances from the limbus.

applies also to the oculo-motor factors of fixation and to the ocular movements connected with the essentials for binocular vision. Certain factors are so important that they must be mentioned here. The attachments of the tendons of the recti muscles as these lie about the limbus are illustrated in Figure 120. The direction and course of the oblique muscles have a similar importance. With these, however, the anterior-posterior diameter of the eyeball, as seen in axial ametropia, is the modifying factor in the

distance of the insertions from the optic nerve. Figure 121 shows clearly the various axes of importance, for with oblique muscle surgery the position of the insertions is almost solely important. These measurements given above are those of Peter's combined with Whitnall's and Duke-Elder's. Naturally there is considerable individual variation, but in general they are accepted as outlined. The important surgical application of these measurements is rather evident. Advancements are limited definitely by the distance of the insertion from the limbus. Hence, an advancement of an internal rectus must be limited in the degree obtainable, as compared to the advancement one can obtain in operating upon the external rectus. The greatest advancement possible would be upon the superior rectus, though the least recession possible would be with this same muscle. The greatest effect which can be obtained through a recession is with the internal rectus. The inferior rectus with its "insertion distance" approximately midway between those distances of the internal recti and of the external recti should have no great differences in those comparable amounts obtainable through an advancement or a recession.

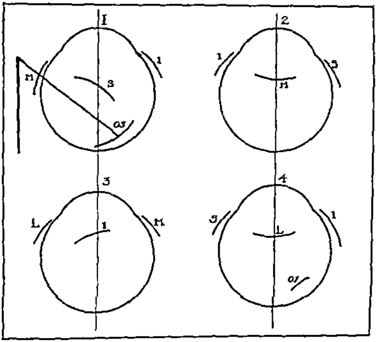

FIG 121.—Scleral insertions, recti and obliques (After Merkel in Whitnall's Anatomy of the Human Orbit, courtesy of Oxford University Press)

The angle Gamma, also spoken of by some authors as the angle Kappa, is an anatomical condition which must be considered in most cases of the lateral oculomotor deviations. The angle involved is that between the visual axis and the pupillary axis passing through the center of the pupil normal to the cornea. The angle is spoken of as positive when the pupillary axis is temporal to the visual axis, and negative when the pupillary axis (pupillary center) is nasal to the visual axis. Quoting Pascal:[1] "Also, if

[1] Pascal, J. I.: Memory Aids in the Measurement of Strabismus, Am Jour Ophthal., Ser. 3, vol. 26, No. 3, March, 1943.

is going to be necessary. In general 75 per cent of monocular convergent strabismus and 90 per cent of divergent squint, both monocular as well as divergent alternating, is to be corrected by surgery, but the surgery is not to be carried out until the time for it is correct. If a child is so old that occlusion produces little or no further improvement in the amblyopia other than that initial jump-up in acuity after the first days of enforced concentration, then any occlusion will have equally little effect on the ingrained facultative macular inhibitions and the secondary retinal positive correspondence. Similarly in congenital alternating squints the alternating macular inhibitions and the secondary retinal positive correspondence may also defy all treatment except operative treatment completed sufficiently early for the normal combined use and correspondence to be developed thereafter.

SURGICAL PRINCIPLES CONNECTED WITH THE OCULAR MUSCLES

In discussing the surgery of the ocular muscles it is inevitable that one must also carry over into the consideration "certain physiological principles which are inherent to and connected with the extra-ocular muscle," as Peter states. It must be assumed that the reader understands their primary and secondary actions, as well as their surgical anatomy, and that he is aware of their synergistic as well as antagonistic actions, as a detailed consideration of these physiological principles is impossible here. This

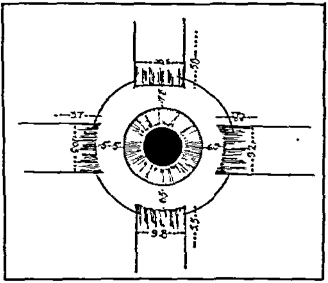

FIG. 120—Diagrammatic measurements of the insertions, tendon lengths, widths and distances from the limbus.

applies also to the oculo-motor factors of fixation and to the ocular movements connected with the essentials for binocular vision. Certain factors are so important that they must be mentioned here. The attachments of the tendons of the recti muscles as these lie about the limbus are illustrated in Figure 120. The direction and course of the oblique muscles have a similar importance. With these, however, the anterior-posterior diameter of the eyeball, as seen in axial ametropia, is the modifying factor in the

distance of the insertions from the optic nerve. Figure 121 shows clearly the various axes of importance, for with oblique muscle surgery the position of the insertions is almost solely important. These measurements given above are those of Peter's combined with Whitnall's and Duke-Elder's. Naturally there is considerable individual variation, but in general they are accepted as outlined. The important surgical application of these measurements is rather evident. Advancements are limited definitely by the distance of the insertion from the limbus. Hence, an advancement of an internal rectus must be limited in the degree obtainable, as compared to the advancement one can obtain in operating upon the external rectus. The greatest advancement possible would be upon the superior rectus, though the least recession possible would be with this same muscle. The greatest effect which can be obtained through a recession is with the internal rectus. The inferior rectus with its "insertion distance" approximately midway between those distances of the internal recti and of the external recti should have no great differences in those comparable amounts obtainable through an advancement or a recession.

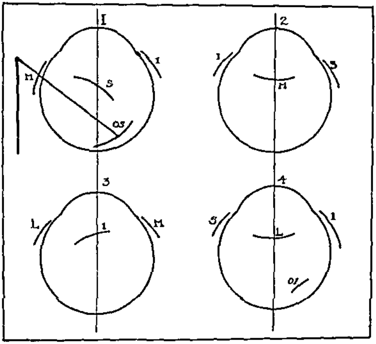

FIG 121.—Scleral insertions, recti and obliques (*After Merkel in Whitnall's Anatomy of the Human Orbit, courtesy of Oxford University Press.*)

The angle Gamma, also spoken of by some authors as the angle Kappa, is an anatomical condition which must be considered in most cases of the lateral *oculomotor deviations.* The angle involved is that between the visual axis and the pupillary axis passing through the center of the pupil normal to the cornea. The angle is spoken of as positive when the pupillary axis is temporal to the visual axis, and negative when the pupillary axis (pupillary center) is nasal to the visual axis. Quoting Pascal:[1] "Also, if

[1] Pascal, J. I.: Memory Aids in the Measurement of Strabismus, Am Jour Ophthal., Ser. 3, Vol 26, No. 3, March, 1943.

when locating it on the perimeter the examiner has to move temporally to get the reflected light from his ophthalmoscope into the center of the pupil the angle is positive. If the examiner has to move nasally to place the light in the center of the pupil, the angle is negative."

It is easy to understand why the positive angle gamma (the value of the angle) has to be added to the total in cases of convergent squint and deducted in cases of divergent squint. Also, why the angle gamma when negative must be deducted in cases of convergent squint and added in cases of divergent squint. Those who constantly work with such measurements need no memory aid. But those who do not make these measurements often will be helped by a memory aid, found very useful in teaching. The following table gives the scheme (Pascal):

	Angle gamma	Squint	
(1)	Positive	Convergence	Add
(2)	Positive	Divergence	Subtract
(3)	Negative	Convergence	Subtract
(4)	Negative	Divergence	Add

Convergent squint may be thought of as a positive condition, both because it is the common form of squint and also because convergence is generally referred to as a positive action. Divergent squint may be thought of as a negative condition, both because it is infrequent and also because divergence is often referred to as "negative" convergence. Pascal states:

"When the angle is positive and the condition is positive as in (1) we have plus by plus which gives plus, therefore add.

"When the angle is positive and the condition negative as in (2) we have plus by minus which gives minus, therefore subtract.

"When the angle is negative and the condition positive as in (3) we have minus by plus which also gives minus, therefore subtract.

"When the angle is negative and the condition negative as in (4) we have minus by minus which gives plus, therefore add."

The assumption of new and strange functions by the cerebral cortex is a well established fact in neurology. A similar example of this lies in the nuclear and the supra-nuclear connections of the fourth nerve. The superior oblique muscle can be utilized very readily as an internal rotator in complete third nerve paralysis. Its action following such reconstructive surgery is not wholly that of a splint to keep the eyes parallel. Internal rotation, by means of the transplanted superior oblique is developed, and still the function of the trochlear nerve under normal conditions is quite opposite. A somewhat different phenomenon occurs with the transplantation of tendon slips of the superior and the inferior recti for a complete sixth nerve palsy. (This procedure lends itself especially well to congenital paralysis and to the paralysis from birth trauma. Acquired sixth nerve palsies, in later years are also amenable to the procedure but the results are never quite as beautiful.) The two obliques functioning together as external rotators (the one balancing the other), move the eye toward the mid-line. The advancement of the paralyzed external rectus, plus the "stay"-like effects of the tendon and muscle slips from the superior and inferior recti, plus the recession of a contracted internal rectus, plus this external rotation of the two obliques, permits a lateral rotation beyond the mid-line. It is quite improbable that the superior and the inferior recti, which are together

internal rotators, should add a third directly opposite lateral rotation function (their primary function being either *elevation or depression*). This augmentation of the obliques in their external rotation ability, past the mid-line (and hence greater in amount than that which they are normally supposed to achieve), is the probable reason for the successful results which can be obtained by this procedure.

The peripheral distribution of the third nerve and the *connections* with the ciliary ganglion in the orbit are shown in Figure 122. The third nerve, superior branch, supplies the superior rectus and the levator palpebræ superioris; this common branch lies between the two muscles, the innervation to the upper of the two entering below, and to the lower of the two above. At times this branch does not subdivide into the lesser branches until it lies between the two muscles. In other instances the subdivision *may occur when the nerve is still in close proximity to the optic nerve*. The branch to the inferior oblique and the short root to the ciliary ganglion arise from the same subdivision. The inferior rectus, the inferior oblique, and the internal rectus with the short root to the ciliary ganglion therefore arise from the lower of the main subdivisions.

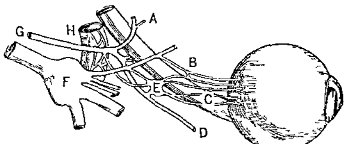

FIG. 122.—Schematic drawing of the nerve supply to the ocular muscles. *A*, superior division of the third nerve, *B*, long ciliary nerve, *C*, short ciliary nerves, *D*, nerve to the *inferior oblique*, *E*, *ciliary ganglion*, *F*, *Gasserian ganglion*, *G*, *trunk of third nerve*, *H*, *internal* carotid, *I*, optic nerve.

The eyeball does not move within the capsule as if it were within a socket, instead, the capsule moves with the eyeball. The great pain which is present in a suppurative tenonitis upon movement of the eyeball, convinces one of the laxity of the muscle sheaths of Tenon's capsule and of its extensive nerve supply. The capsule has no communication with the perichoroidal spaces, nor does it contain lymph. Further, Tenon's capsule in its investment of the optic nerve at the posterior portion of the orbit, seals off the vaginal space of the meninges from the orbit without any connection between Tenon's capsule and the intra-cranial cavity. The fascial sheaths are especially important because of their relationship to muscle surgery. Under certain circumstances, as in recessions, the sheath can be readily receded with the tendon. On the other hand, in tuckings, the tendon and the adjoining muscle fibers must be dissected free from the sheaths to obtain satisfactory results. This procedure applies also to advancements and resections. In tendon transplantation, as in those of the superior and inferior recti, and in the transplantation of the tendon of the superior oblique, new channels must be made through Tenon's capsule, for this tendon. The surgery of Tenon's capsule cannot be harsh, however.

If this is permitted, the resulting cicatrix will attach the transplanted tendons to the eyeball in such a manner that there will be no result obtained, as a result of the surgery, except fixation of the tendon to the eyeball. Two most important subsections of the fascia of the orbit are the internal and the external check ligaments. Peter has been insistent, in his publications on ocular muscle surgery, as to the value of these and the relationship which they have toward tenotomies. Figure 123, illustrates these two check ligaments. In Peter's[1] discussion of them he describes them as ailerons.

Two at least are especially well defined, the external and the internal. The external ligament is a broad well-developed band extending from the muscle sheath to the periosteum over the zygomatic tubercle and also to the external canthal ligament. Similarly, the internal ligament extends to the inner wall of the orbit and the internal canthal ligament. Both ligaments send off shoots to the conjunctiva. The superior and inferior ailerons are not so well marked but they are present and

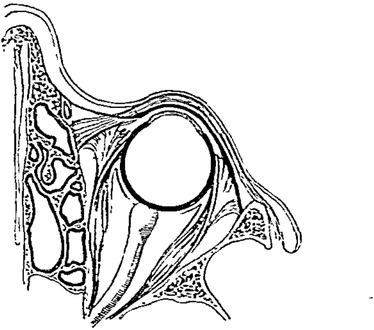

FIG 123.—Check ligaments from behind. (After Whitnall, Anatomy of the Human Orbit, courtesy of Oxford University Press.)

can be demonstrated by Howe's method of holding the dissected fascia before a bright light when the thickened tissue is plainly visible. The clinical importance of the check ligaments rarely receives proper consideration. (1) The orbital attachments steady and firmly anchor the eyeball and counteract the backward pull of the four recti muscles; (2) the ligaments serve as a check upon the action of the individual muscles. Not only do they limit the over-action of a muscle, but it is more than likely that, being elastic, the action of a muscle, as it nears its maximum contraction, is gradually slowed down and the contraction is smoother than it otherwise would be. That a check ligament actually limits the action of a muscle is easily demonstrated by severing one of these tendinous attachments, after which the muscle will rotate the eye through a greater arc. Of special interest from a surgical standpoint, is the effect which these ailerons may have upon tenotomies and advancements. After a tenotomy of the internal rectus, for example, the tenotomized muscle retracts and reattachment may be incomplete because of the action of the check ligament. If the muscle becomes reattached, the arc through

[1] Extra-ocular Muscles, 3d ed., Lea & Febiger, p. 22, 1941.

which the eyeball can be rotated is much diminished, partly because of its reattachment nearer to the equator of the globe, but *more especially because the check ligament* already taut, cannot admit much greater extension of its elastic fibers. As a result, therefore, of tenotomy of the internal rectus there may be permanent insufficiency of converging power and sustained close work is apt to be most uncomfortable and, in instances, impossible. The action of the check ligament, after a muscle advancement, aids, or at least admits of an increase in the rotational power of the muscle. This is in marked contrast to the crippling effect produced by a tenotomy. It furnishes the thoughtful ophthalmic surgeon with much evidence in favor of *advancement or resections and against tenotomies.*

In reattaching a formerly tenotomized internal rectus because of a secondary divergent strabismus (the former convergent strabismus, having been operated upon by tenotomy) the internal rectus may not be attached to the eyeball at all but instead may be found adherent to the medial wall of the orbit. The receded caruncle and the posterior drag of the inner canthus when contralateral rotation is attempted will demonstrate this. In such instances it may be necessary to place the strabismus hook, not between the eyeball and the muscle, but between the muscle and the orbit, as it is to be picked up for subsequent reattachment to the eyeball. Tenotomy of the external rectus is not as serious an offense because of the weaker check ligament and because of the lesser rôle that it plays. Still, *with recession at our command there is no reason for doing a tenotomy of* the recti muscles under any but extraordinary circumstances. The indications for a *tenotomy* of the posterior or inferior obliques are so definite and so different from any assumed, at present, for the four recti, that an entirely different matter is under consideration.

In a consideration of the muscles as this applies to surgery, attention is again called to the spiral line formed from the limits of one tendon insertion after the other (Fig. 124). This outlines the extremes of the arc of contact. Theoretically, a muscle can continue functioning as long as a line parallel to the direction of its pull continues tangently to the surface of the globe. It has reached its maximum theoretical action when this line becomes continuous with a radius of the globe. The position of the eyeball within the socket, Tenon's capsule, and the remaining antagonistic muscles naturally *prevent such unbridled action. The line of force, therefore, can be* considered as an ever changing point which lies upon the sclera at that place where the muscle tendon, or muscle belly, lifts or departs from the sclera in rotating the eye. One can see, therefore, how a resection, with an advancement, might cause tenseness of a check ligament, which, when added to scleral adhesions from the surgery, would nullify in part the rotational effects hoped for from the surgery; the impairment being due to a limitation in the arc of contact. Reversely, a recession should permit laxness of a check ligament, and while this operation minimizes, automatically, the available arc of contact, the greater amount *of rotational effect resulting* from the laxity of the check ligament offsets the undesirable mechanical results *from a recession. A properly performed* tendon tucking should not change the anatomical relationships of tendon, sclera, and the arc of contact. Sketches in Figure 125 show this difference in an arc of contact of the external rectus, looking down from above, when the eyeball is directed to the front and when it is in lateral rotation. Naturally, therefore, the greater the arc of contact the greater are the possibilities for rotational power of the muscle. This is one of the principles of muscle advancements.

in that not only is the muscle actually shortened, but also its advancement in front of the original tendon stump, theoretically increases the possibilities for greater rotational abilities. Certainly, following advancement where one has been harsh in the handling of his tissues, this desired result is not obtained. In fact the advanced muscle may become so adherent to the eyeball that its arc of contact is actually shortened. To obviate this, and at the same time to minimize the possibility of postoperative adhesions, Berens recently recommended[1] the insertion, with sutures, of a piece of Tenon's capsule over the roughened sclera beneath the muscle so that as the muscle is advanced in front of the stump, new and unwanted adhesions will not develop behind the stump between the muscle and the sclera.

There are so many anatomical, physiological, and psychological factors which enter into muscle surgery and binocular vision, that it is absurd to speak of results obtainable through certain surgical procedures without considering many other tangible as well as intangible factors. To oper-

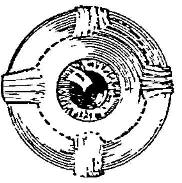

Fig. 124.—The insertion spiral of the recti. (After Motais in Whitnall's Anatomy of the Human Orbit courtesy of Oxford University Press.)

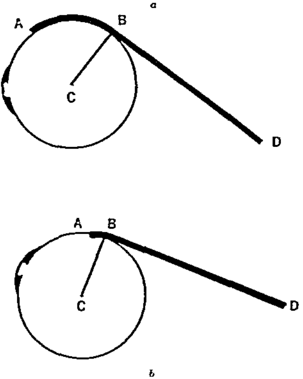

Fig. 125.—Illustrating the arc of contact; in *b*, the eyeball has moved upward, and *A* and *B* are close together.

ate and to direct the visual axis of an eyeball within the orbit through surgery, at any desired angle, as if one were "opening a door to a certain angle," is perfection rarely if ever achieved. This is not spoken regretfully, but it is relevant here to call attention to the very necessary orthoptic training which must follow as well as precede muscle surgery.

The value of orthoptic training is well established. At the same time, much has appeared in the literature recently, relative to the orthoptic training and to the results of orthoptic training, which not only is of no value to the subject itself but which also, unfortunately and unfairly, does damage because of unwise statements, inaccurate observations, and unwarranted conclusions. Orthoptic training is based upon sound and scientific principles. Too often these principles are either not understood by the orthoptist, or even worse, they are disregarded.

[1] Am. Jour. Ophth., vol. 21, May, 1938.

It seems as if Lancaster's attitude toward orthoptics and surgery is most logical.[1] According to his view, the chief value in orthoptic training lies in its effect on the activity of the supranuclear centers and not on a strengthening of the muscles themselves. It must therefore depend upon the capacity of the fusion faculty[2] for the necessary educational development. The value and purpose of the surgery is merely to change the position of the eyeball in the orbit so that a less amount of neuro-muscular-fusion faculty adjustment is necessary. It does not attempt to strengthen or weaken a muscle.

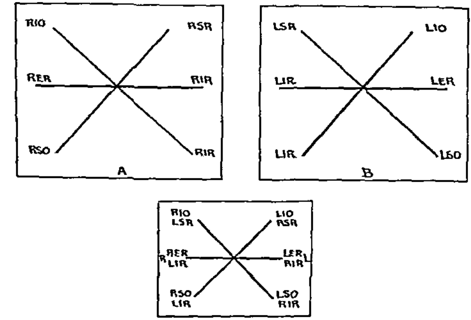

FIG. 126.—Action of the individual muscles from primary position, and grouped together as yoke muscles (Peter)

Figure 126 is a graph to illustrate the action of the individual ocular muscle of each eye from a primary position. The right superior rectus and the right inferior rectus, by reason of their 23 degree angle with the entire posterior axis of the eyeball, are of necessity internal rotators. The right inferior and superior obliques by reason of their 50 to 54 degrees posterior inclination of their tendons (with the broad insertion of the muscle into the sclera behind the center of rotation), must of necessity be external rotators. Therefore, in a consideration of surgery upon the eyeball, these graphs must be constantly in the minds of the operators. In binocular movements, however, a superposition of these two charts must be assumed, one upon the other. Coördination of these movements is a cerebral function. If

[1] Arch. Ophth., vol. 17, June, 1937.

[2] Duke-Elder (Textbook of Ophthalmology, C. V. Mosby Company, 1933, Vol. I, pp. 1035 and 1038) has discussed this so well that it must be included herein, at least in part ". . . all the evidence is against the existence of an inborn 'fusion faculty,' to a congenital deficiency of which the primary cause of squint has been ascribed by Worth (1903) and others. This does not mean that no anatomical basis for the central process exists, but it must be subserved by conditioned reflexes making use of association pathways." (See writings of Aubert [1865], Heine [1901], Worth [1903], and Verhoeff [1925], etc.) The "unification" theory of Verhoeff as to single binocular vision and those rôles played in developing and maintaining single binocular vision, as corresponding retinal points (and the opposite, disparate retinal points) ocular dominance, retinal rivalry, etc., seem to answer this question of a fusion faculty adequately. (See introduction to this chapter.)

the two charts, then, are superimposed, the muscles are grouped as yoke or conjugate muscles in their action as lateral rotators and as right and left hand elevators and depressors when the position on this chart of the recti (superior and inferior) and the obliques is reversed. The first is that of normal eyes-front action; the second arrangement is that present when pathology is present with any of the extra-ocular muscles. The value of this graph can easily be understood by a concrete case. In an instance of superior oblique paralysis, in eyes front, the left eye is in hypertropia and the right eye is fixing. As both eyes move to the right, the left eye is directed even more upwards by reason of the unopposed pull of the left inferior oblique, now in a position for maximum elevation. At the same time the right eye moves downward as the left superior oblique is conjugate with the right inferior rectus, and the innervational effort put forth in an attempt to hold the paralyzed left superior oblique in its proper function "spills" over into its yoke muscle, in this instance, the right inferior rectus; and a downward overaction of the right eye results.

Logical surgery, therefore, for a paralysis of a left superior oblique would be a recession of the right inferior rectus. This example of the conjugate yoke muscles continues throughout the action of all of these muscles into the four cardinal movements of up and to the right, and down and to the right, up and to the left, and down and to the left. Another glance at the graph also illustrates the inclination of the corneal meridian as the result of the action of these muscles. Paralysis of the right superior oblique will result in a temporal tipping of the corneal meridian, the declination being measured as from the upper end of the meridian, and resulting from the unopposed pull of the intact inferior oblique. It is a fact that this inclination of a false image as an accompaniment of hypertropia (or hyperphoria) from an oblique palsy is responsible for the largest amount of the patient's discomfort. The vertical displacement is correctable by prisms, but the inclination of the image, from the involved eye, cannot be corrected in this manner. The cause can be seen in Figure 126, by the inclination of the line, RIO-LSR.

As to the overshooting, it is exactly similar to the greater secondary deviation which appears in the normal eye, in such a case of internal rectus palsy behind a cover, when the patient is compelled to fix with the paralyzed eye. Overaction and underaction can be gauged accurately only by the study of the ductions and not by a study of the rotations. Faulty ductions and heterophoria go hand in hand, *pari passu*. A divergence excess will show an exophoria, but a convergence insufficiency may also show it. The reverse is likewise true, a convergence excess will have as an accompaniment, esophoria; also a divergence insufficiency will have the same form of muscle unbalance.

The point is of importance in studying a case wherein one must decide, "the advisability of an advancement of one muscle or the recession of its contralateral antagonist." Surgery of the ocular muscles must be, first, of a constructive nature, and destructive only when necessary.

One cannot accurately express a function—almost properly called an act of cerebration—in a concrete mechanical form, as expressed in prism diopters. The interpretation of the findings is the only important fact. Three factors must be considered in the surgery of the ocular muscles, especially in the surgery of the phorias, (*a*) the ocular rotations, (*b*) the

muscle balance, and (c) the ductions. One cannot arrive at sound surgical judgment until they are understood and investigated in every individual under surgical treatment.

INSTRUMENTS FOR SURGERY OF OCULAR MUSCLES

In the surgery of the ocular muscles, in spite of the fact that many operators seem lax with their instruments in the types of forceps and hooks used, and casual with the selection of the type of suture to be used (either silk, twisted, or braided; or catgut, plain and chromic), every operator, early in his experience, becomes accustomed and attached to certain instruments. The author holds no brief for the selection of one instrument over another, as long as an instrument functions upon sound, logical, and scientific principles. For instance, considerable dissection is done upon and through the conjunctiva, and unless the lashes are covered by the lips of the speculum, it is almost certain that, sooner or later, tiny clippings from the lashes will fall into the wounds. White, of New York, once made the statement that every ophthalmologist suffering with insomnia has devised an operation for strabismus. The quotation is humorous, the state of affairs which makes it a truism is unfortunate. One operator will use an advancement forceps with toothed jaws, another with ribbed jaws, a third with jaws which fit one into the other as the so-called male and female parts of any mechanical devices. An adequate and secure grasp is the one thing necessary. The underlying principle is this; no forceps must be used, for any procedure, except that the tendon within the grasp of the forceps is to be resected and discarded subsequently. Sutures tied into a muscle hold only by reason of their own tension; hence, the fibers enclosed within the knot are certain to slough. Every one has picked from the conjunctival cul-de-sac sutures which were properly tied, from tendon to sclera, ten to fourteen days before this, demonstrating conclusively the development of such a slough. This principle is violated frequently, and tendon tuckings and muscle sutures which divide the muscle into two halves, equally tied, is a slow but certain means of making a complete tenotomy. Cases which do not develop this catastrophe, where such sutures are used, are saved from it only by the adhesions of the muscle and the capsule to the sclera at a point where the sutures rest upon the sclera. *Considering this point* as the apex for the new arc of contact of the muscle, one may achieve noth-*ing whatsoever from the tucking. The one nullifies the other, and the end-*result is disappointment. There is no doubt that the shortening which follows the O'Connor cinch operation is the result of a slough occurring early in the twisted muscle strands, a tunnelization of this slough and the immediate cicatrization of the position where the dermol sutures lie. Rough surgery means subsequent adhesions, displacement of the reattached tendon stump, and the development of undesirable rotational defects. An unnecessary removal of the capsule means subsequent adhesions. Different operations are best applied to the varying degrees of the phorias and the tropias. Attempting the same operation for different degrees of squint shows faulty judgment. Peter's simile applies so aptly, "in golf, a mashie cannot be used for the same distance shot as a midiron." A brutal muscle resection with advancement will give more correction than that for which it is best planned. Enophthalmos and limitation of motion, however, will develop. An advancement is limited by the distance which lies between the limbus

and the point to which the tendon is normally inserted. A recession suture cannot be attached to the sclera at the equator of the eyeball and the operator expect, following the surgery, normal prism ductions. Sutures can be placed into the sclera at any point and at any time with impunity. They should not go through the sclera, and if the operator will watch the point of his needle and keep that in view at all times through the translucent superficial scleral fibers, perforations of the globe need never occur. A needle holder is necessary to grasp the needle firmly. Worth's needles, or some type similar to these, should be used. Needles, round in cross-section, cannot be readily passed, and needles which are triangular in cross-section will tear out. Silk sutures should be waxed before they are pulled through scleral and muscle fibers. The standard wax preparation known as bone wax is best for this. The formula Peter used is 7 parts of yellow beeswax, 1 part of almond oil, and 1 part salicylic acid. It is to be mixed, sterilized, and cooled for use.

The postoperative dressings are important. If the surgery is such that results might be assisted by a decrease in the accommodation-convergence —then postoperative atropinization is indicated; otherwise none is to be used. All operations, with perhaps the exception of the O'Connor cinch operation, should have several days of physiological rest immediately postoperative; hence binocular dressings are indicated. It is a well known fact that an advancement with a recession of the antagonist gives a nicer postoperative result than a wide advancement with resection alone. A certain modicum of physiological rest is given to an advanced muscle by the retro-placed position of the receded antagonist. The conjunctival reaction following a tucking is always more marked because of the strangulation of these fibers and the resulting edema of the contiguous parts. In general the mechanical essentials of muscle surgery are: (*a*) to move the insertion of a muscle forward or backward upon the sclera a certain definite amount; (*b*) to be sure that sutures are properly tied, properly placed, and that they will hold the transplanted muscle tendon in this new position sufficiently long for normal healing, (*c*) to do no more damage than is absolutely necessary to other surrounding and adjacent soft tissues; (*d*) to be reasonably certain that the results present at the end of the operation are the results which will be found after healing has occurred. Lancaster's essentials, as quoted in Berens,[1] are as follows:

> The two things for which we strive in operating are a position of orthophoria since, other things being equal, the nearer the eyes to a position of orthophoria, the less the task of the neuromuscular mechanism in maintaining binocular vision. Second, an effective range of fusion, this being, if possible, even more important than the former. A neuromuscular mechanism which, because of defective working of the controls, produces an exophoria, for example, may be made to produce an orthophoria by so shifting the position of the eyes in the orbits that approximately the same working of the controls will now result in orthophoria because the eyes start from a position nearer the ideal one. The idea that the purpose of operating on the ocular muscle is to weaken or to strengthen some muscle which is too strong or too weak is unsound physiologically.

ANESTHESIA IN OCULAR MUSCLE SURGERY

The anesthesia to be used depends upon the age of the patient and the extent of the surgery. Naturally all children must be operated under

[1] The Eye and Its Diseases, W. B. Saunders Company, 1936.

general anesthesia. Adults should be done under local anesthesia unless the patient is of such a temperament and disposition that he cannot or will not coöperate with the operator. Preoperative sedatives are necessary. The instillation of anesthetic drops is not sufficient, but the injection of a too great amount of anesthetic into the muscle sheaths results in an edematous gelatinous consistency of the fascia and important landmarks become obscured. Block anesthesia must be used for surgery upon the obliques. Adequate anesthesia will permit all manipulation necessary, but even excess anesthesia will not permit undue tugging of the muscles and tendons with a muscle hook. Marshall quotes Larsson,[1] relative to this, for with the manipulations necessary to the muscles during retinal separation surgery, there is no doubt that the severe pains which occur in his patients so often after surgery are due to the fact that he prefers to put aside the muscle with ligatures rather than dividing them temporarily. It is an interesting observation.

SURGICAL TECHNIQUE OF OPERATIONS UPON THE EXTRA-OCULAR MUSCLES

The surgical procedures in general may be grouped under five headings: (1) tenotomies; (2) recessions; (3) resections and tuckings; (4) advancements; and (5) transplants. Tuckings must include O'Connor's cinch operation, basically a tuck. Practically, a tuck is also a resection, for it does remove from function a portion of the muscle, and, while there is no rejoining of cut ends, the result is the same. Further, an advancement is seldom done without some resection at the same time, though a "whip-stitch suture reattachment" of a formerly tenotomized internal rectus is a pure advancement without resection. Frequently, one or more procedures are combined in a surgical attack, the various procedures either being simultaneously carried out, or with stated intervals of time between them. In general, operations fall within these classes depending upon the degree of deviation present.

The general rules for surgical procedures for concomitant and non-concomitant squint are different as the degree of deviation varies. In concomitant squints even the alternating types respond somewhat differently than do the monolateral cases in so far as surgery is concerned. That difficulty of obtaining parallelism in the alternating form of strabismus demands even more exact surgical correction.

The surgery for the tropias differs somewhat from the surgery necessary for the phorias. The rules separating one from the other are not hard and fast, because from a surgical standpoint it is difficult to decide the exact threshold which is present separating one from the other. Physiologically, this is somewhat different. Such characteristics as a manifest deviation, fixing and non-fixing eyes, alternation, the absence of diplopia, the proportion present between prism abduction and prism adduction, are all too well-known to be considered here. In spite of this, a certain percentage of hyperphoria is not the result of innervational defects. Instead, they are minimal cases of paresis of the superior or inferior rectus muscle, the obliques being much less frequently involved. Further, the degree of hyperphoria is not an indication of the amount of disability present. Slight

[1] Detachment of the Retina, Oxford Medical Publications, 1936.

amounts may be the cause for marked symptoms, while decidedly large degrees are seen with the patient wholly symptom free. Further, the symptomatology does not depend upon whether the deviation present is a hyper- or a hypophoria. Perhaps the reason for the absence of symptoms in a small number of those cases with a moderate degree of hyperphoria is due to the fact that these are correcting their diplopia, or their diplophobia, by a compensatory head-tilting. White's rules for operative procedures in the phorias follow herewith in abstract.[1] They are the observations of great experience, hence, of great value. (1) Operative procedures should not be resorted to until other means have been thoroughly tried for relief. These include the treatments of possible constitutional causes, the wearing of prisms, and the use of prisms for exercise. Surgery should never be undertaken unless there is a reasonable chance for improvement of symptoms. (2) In some instances, operative cases are not relieved. This is not due to the fact that the operation may have been contraindicated or improperly done, but because the wrong muscle or muscles were chosen for the surgery. (3) In general, in hyperphoria, a resection or tucking of the paretic muscle is preferred over an advancement, first, because of the relatively small amount of correction necessary, and second, because the original insertion is used and a postoperative torsion is less liable. Tenotomy of the associated and antagonist muscle is occasionally a still better procedure. This is best seen in the indicated tenotomy of the inferior oblique muscle for a paresis of the superior rectus of the opposite eye, though even here, when the paresis is not marked and the secondary-deviation is slight, a resection of the superior rectus might be preferred. (AUTHOR: see subsection on Recession, of the inferior oblique.) (4) In paresis of the superior oblique muscle, a recession of the associate and antagonist, that is, the inferior rectus of the opposite eye, is advisable.

(5) Examples of improper surgery are as follows: (a) "Given an example case of right hyperphoria, as the right eye is higher, tenotomy of the right superior rectus is done. The right hyperphoria, however, was due to a paretic right inferior rectus, and now following operation, a paretic superior rectus of the same eye has been added to the original condition." (b) "A second case of hyperphoria in which the left superior rectus was advanced to bring the left eye up to the hyperphoric right, where the original trouble instead was a paretic right inferior rectus." (6) In examining every case of hyperphoria for surgery, the amount present should be measured for distance and near, but even more important, it should be measured in the six cardinal fields, to obviate mistakes in surgery as just quoted in 5, above. The measurement of the hyperphoria is especially valuable and important in the upper and lower outer corners. (7) The screen and parallax test with the amount of deviation measured by prisms is the best test for these corners. The deviation for distance and near in this mid-line, may be made by any of the large number of tests available, but since the screen test must be used in every case, it is convenient to use this method for the primary position measurement as well. (8) One must always bear in mind the fact that some patients with hyperphoria have learned so well to overcome it, that it may not be the cause of their symptoms. Under such circumstances, the only way to decide this conclusively is to prescribe prisms with the proper advice, so that they are to be removed if not well tolerated. (9) Contraindications for surgery are: "(a) When there is still a

[1] Arch. Ophth., vol. 7, May, 1932.

possibility of a change in the amount or character of the hyperphoria. This may be due to a change in the course of the disease or as a result of treatment, systemic or otherwise. (*b*) When the patient has not suppression of the false image, but because it is so far from the true image, it does not annoy. When an operation is performed in this case, the false image may approximate the true image so closely that it would be very troublesome, if for any reason the patient was unable to fuse the images. (10) When the operation is decided on, determine whether to (*a*) resect the paretic muscle, (*b*) tenotomize the associate antagonist or (*c*) tenotomize the direct antagonist. The choice will depend on the amount of paralysis and also on the amount of the secondary deviation and the secondary contracture. Not infrequently, the operator may have to resort to any two or all of these procedures."

TABLE 1.—RULES FOR DECIDING ON SURGICAL PROCEDURE FOR NON-PARALYTIC FORMS OF THE LATERAL TROPIAS[1]

Degrees Squint (*a*)	Convergent	Divergent
(*a*) 10°	Tucking external rectus	Tucking internal rectus
(*a*) 10° to 15°	Tucking external rectus or recession internal rectus. (*b*)	Advancement or tucking of internal rectus
(*a*) 15° to 20°	Recession internal rectus (*b*) or advancement external rectus	Tucking internal rectus with a recession of external rectus at the same time
20° to 30°	Advancement of external rectus with resection of tendon At a later period, recession of internal rectus Tucking of external rectus with recession of the internal rectus at the same time	Advancement of internal rectus with recession external rectus at the same time (*c*)
30° to 40°	Advancement of external rectus with resection of tendon and recession of internal rectus at the same time. Recession of the internal rectus opposite eye or tucking of external rectus opposite eye to be done at a later period.	Advancement of internal rectus with resection of tendon Recession external rectus at the same time Tucking or advancement of internal rectus opposite eye later period
40° to 45°	Advancement of external rectus with resection of tendon Recession of internal rectus same time. Advancement of external rectus with resection of tendon opposite eye later period Recession of internal rectus may be necessary at the same time	Advancement of internal rectus with resection of tendon Recession of the external rectus Advancement of internal rectus with resection of tendon opposite eye, later period. Recession of external rectus at the same time The eyes done separately but both muscles in one eye operated simultaneously
45°	Double advancements of both external recti with resection of tendon with double recessions of both internal recti each eye operated separately, but both muscles of one eye operated simultaneously	Advancements, resections, and recessions must be of maximum degree possible, on both eyes, each eye operated upon separately but both muscles of one eye operated upon simultaneously

(*a*) Demands for the correction of the phorias are slightly less rigid than are those connected with the correction of the tropias.

(*b*) Recession, especially if convergence increases at the near point

(*c*) Advancements and resections are anatomically limited upon the internal rectus. Recession of the external rectus of the opposite eye, at a later period.

[1] In the discussion of the lateral deviations, one must remember that vertical anomalies are a frequent complication See White's rules in chart on the phorias, page 185.

TABLE 2.—RULES FOR DECIDING ON SURGICAL PROCEDURE FOR THE PHORIAS

Phoria	Individual type	Surgery
Exophoria	Accommodative exophoria as with myopia, convergence insufficiency near only, proportionate to degree of myopia.	Tucking of one or both internal recti.
	Convergence insufficiency exophoria for near and for distance, measurement of prism ductions show *the duction defect in the upset adduction-abduction ratio*	Tucking of one internal rectus, or both. May need at times recession of one external rectus as well.
	Divergence excess, exophoria for both near and distance, may even be equal in amount for the two. Prism duction tests show the marked abduction increase over adduction in the upset adduction-abduction ratio.	Recession of both external recti.
Esophoria	Convergence excess, esophoria in proportion equal to or even greater at near than at distance. Prism duction tests show adduction preponderance	Recession of both internal recti.
	Divergence insufficiency, esophoria for both near and distance. Prism duction testing must be *carefully carried out to determine* the divergence insufficiency factor.	Tucking of one or both of the external recti.
Central convergence paralysis	Condition is essentially one of divergence excess.	See above.
Central divergence paralysis	Case is essentially one of convergence excess	See above.
Hyperphoria (a)	In general surgery to be directed to the hypophoric eye though it may be necessary to divide this between the two because of a great degree of hyperphoria	Double hyperphoria is not a surgical condition, instead (Bielschowsky) is a pure innervational defect.
	Spasm of an elevator	The surgery of this variable form of hypertropia is considered under paralytic strabismus.
	Less than 10°.	Recession of the overacting muscle on the hyperphoric eye. (See Lancaster's statement, page 117.)
	10° to 15°	1. Tucking of the underacting muscle on the hypophoric eye may be combined with a minimal recession of the overacting muscle of the hyperphoric eye. 2. Tucking combined with recession of an antagonist on the same eye is usually not recommended for hyperphoria of less than 20.

TABLE 2.—RULES FOR DECIDING ON SURGICAL PROCEDURE FOR THE PHORIAS—*Continued*

Phoria	Individual type	Surgery
	15° to 20°, and over.	Tucking of the underacting muscle on the hypophoric eye combined with tucking of the underacting muscle on the hyperphoric eye to be done in two stages. A recession of an underacting muscle may be necessary. O'Connor cinch operation on the underacting muscle of the hypophoric eye or the underacting muscle of the hyperphoric eye.

1. In operating for hyperphoria surgery must be directed toward the lesser measurement considering the hyperphoria for near and for distance.

2. Double hyperphoria is an innervational problem and must not be treated surgically.

3. White. Transactions American Academy of Ophthalmology and Otolaryngology, 1938, abstract of conclusions.

a. No person with lateral strabismus should be operated without a study and analysis of the vertical element.

b. When operating to correct a lateral deviation, the rules are not the same if a vertical factor is present.

c. In cases of convergent strabismus in which it is thought best not to correct the vertical deviation first, there is less danger of overcorrection if the first procedure is resection of one or both external rectus muscles. *Recession of the internal rectus muscle is then left for a finer adjustment* if that becomes necessary.

d. The surgery for uncomplicated convergence or divergence excess if carried out similarly in those cases of convergence or divergence excess with an accompanying vertical factor will likely result in some to gross overcorrection. In a few instances, it may, instead, permit an almost equal amount of undercorrection.

(See Occlusion hypertrophia.)

Cyclophoria	Correction of the accompanying hyperphoria may improve the torsion of a cyclophoria. A recession of an overacting muscle may also decrease the torsion of the cyclophoria.	1. If accompanied by hyperphoria first surgical attack is toward this, utilizing the directions as above.
	Plus cyclophoria	Detaching the superior rectus and reattaching at the position of the stump but more lateralward has a tendency to swing the corneal axis toward the vertical. Detaching the inferior rectus and reattaching at the position of the stump more nasalward gives a similar result though to a less degree.
	Minus cyclophoria	Detaching the superior rectus and reattaching more nasalward has a *tendency to bring the corneal meridian* toward the vertical. Detaching the inferior rectus and reattaching in an opposite direction will give the same result though to a somewhat less degree. Practically there should be no difference in the result *whether applied to the superior or* the inferior rectus. Actually, however, the broader stump of the superior rectus and its greater distance from the limbus permits a greater degree of correction.

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Exophoria	Accommodative exophoria as with myopia, convergence insufficiency near only, proportionate to degree of myopia.	Tucking of one or both internal recti.
	Convergence insufficiency exophoria for near and for distance, measurement of prism ductions show the duction defect in the upset adduction-abduction ratio.	Tucking of one internal rectus, or both. May need at times recession of one external rectus as well.
	Divergence excess, exophoria for both near and distance, may even be equal in amount for the two. Prism duction tests show the marked abduction increase over adduction in the upset adduction-abduction ratio.	Recession of both external recti.
Esophoria	Convergence excess, esophoria in proportion equal to or even greater at near than at distance. Prism duction tests show adduction preponderance	Recession of both internal recti.
	Divergence insufficiency, esophoria for both near and distance. Prism duction testing must be carefully carried out to determine the divergence insufficiency factor	Tucking of one or both of the external recti.
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	Spasm of an elevator	The surgery of this variable form of hypertropia is considered under paralytic strabismus.
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TABLE 2.—RULES FOR DECIDING ON SURGICAL PROCEDURE FOR THE PHORIAS—*Continued*

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a. No person with lateral strabismus should be operated without a study and analysis of the vertical element.
b. When operating to correct a lateral deviation, the rules are not the same if a vertical factor is present.
c. In cases of convergent strabismus in which it is thought best not to correct the vertical deviation first, there is less danger of overcorrection if the first procedure is resection of one or both external rectus muscles. Recession of the internal rectus muscle is then left for a finer adjustment if that becomes necessary.
d. The surgery for uncomplicated convergence or divergence excess, if carried out similarly in those cases of convergence or divergence excess with an accompanying vertical factor, will likely result in some to gross overcorrection. In a few instances it may instead permit an almost equal amount of undercorrection.
(See Occlusion hypertrophia.)

Phoria	Individual type	Surgery
Cyclophoria	Correction of the accompanying hyperphoria may improve the torsion of a cyclophoria. A recession of an overacting muscle may also decrease the torsion of the cyclophoria.	1. If accompanied by hyperphoria first surgical attack is toward this, utilizing the directions as above.
	Plus cyclophoria	Detaching the superior rectus and reattaching at the position of the stump but more lateralward has a tendency to swing the corneal axis toward the vertical. Detaching the inferior rectus and reattaching at the position of the stump more nasalward gives a similar result though to a less degree.
	Minus cyclophoria.	Detaching the superior rectus and reattaching more nasalward has a tendency to bring the corneal meridian toward the vertical. Detaching the inferior rectus and reattaching in an opposite direction will give the same result though to a somewhat less degree. Practically there should be no difference in the result whether applied to the superior or the inferior rectus. Actually, however, the broader stump of the superior rectus and its greater distance from the limbus permits a greater degree of correction.

TABLE 2.—RULES FOR DECIDING ON SURGICAL PROCEDURE FOR THE PHORIAS—*Continued*

Phoria	Individual type	Surgery
Cyclophoria		In the surgery of cyclophoria as applied to the superior and inferior recti, a similar result can be obtained to that above if only the major portion of the muscle is resected from the sclera. The sutures to reattach the resected portion should be carried forward and temporalward on the superior rectus in plus cyclophoria and forward and nasalward on the inferior rectus in plus cyclophoria. The line of insertion then from the uncut portion of the tendon toward the reattached portion of the tendon is oblique and the reattached portion lies closer to the limbus than formerly present. The surgery of minus cyclophoria would be the opposite to that above.

(*a*) Not to include those cases of elevator-depressor paralysis, recti or oblique, congenital or acquired These are essentially cases of paralytic strabismus, a tropia.

Tables 1 and 2 illustrate a general scheme for combining various procedures in the varying degrees of non-paralytic tropia, and in the phorias. Dunnington's rules[1] are an ideal footnote to Tables 1 and 2 as just presented. Dunnington's rules follow herewith verbatim.

Refractive Error.—In an esotropia in which there is present a high degree of hyperopia or of anisometropia, great care must be used in weakening the internal rectus, while in an exotropia of similar nature a liberal weakening of the external rectus may be required.

Visual Acuity.—An esotropia with an uncorrectible amblyopia *ex* anopsia is also an indication for a conservative amount of weakening of the internal rectus.

Fusion.—In the absence of fusion or any prospect of obtaining it although the operation is purely a cosmetic one, a destruction of power of convergence (by too great a recession) will eventually lead to a secondary divergence. If the fusion is present a destruction of power of convergence renders it impossible at near range.

Diplopia—Its presence or absence before operation should be carefully noted and any operative procedure undertaken should be designed to do away with it or else to render it more comitant.

Measurements of the Amount of Deviation.—By this means our most important preoperative information is obtained. A comparison of the findings for distance and near enables us to tell whether it is primarily an anomaly of convergence or of divergence. The measurement in the six cardinal directions of gaze offers definite evidence of its nature—paralytic or non-paralytic. [AUTHOR. See Duane's double V diagram for maximum right and left hand elevators and depressors.]

A study of the movements of the eyes by the comitance test is most useful in young children in detecting underactive or overactive muscles otherwise easily overlooked.

The estimation of the convergence near point is of service in helping us select the operation of choice in both convergent and divergent strabismus. An esotropia manifesting a marked spasmodic inshoot on attempting to converge, certainly calls for a generous recession of the internal rectus. When no such spasmodic inshoot exists, much greater caution must be used in receding the internal rectus. An exotropia exhibiting no power of convergence requires more shortening of the internal rectus than does one with a good relative near point of convergence. An exotropia with a normal near point of convergence is primarily due to a divergence excess; consequently the principal operative interference should be a recession of the external rectus Experience has shown, however, that unless some shortening of the internal rectus is also done an undercorrection results.

Time of Operation and Anesthesia.—Operation should be performed when indicated regardless of age. It is my firm conviction that the vast majority of the deviations should be removed prior to the school age. The reasons for advocating early operation are:

1. A good functional result is more apt to be secured.

[1] Dunnington, J. E.: The Surgical Treatment of Heterophoria and Heterotropia. American Academy of Ophthalmology and Otolaryngology. Section on Instruction, 1941.

2. Secondary muscular changes are less frequent in cases of short duration.
3. Early removal of the cosmetic blemish is important from a psychological standpoint.
4. Postoperative diplopia, if present, is more readily overcome in the young.

Many objections are raised to early operation and chief among them is the necessity for the use of general anesthesia. This objection is largely theoretical, for if one carefully analyzes his case preoperatively he can usually determine beforehand the amount and character of the operative interference needed for its correction. Of course, it is necessary to vary this plan, if unusual muscular conditions are found at operation.

Indications for surgery, according to Travers,[1] are even more interesting because they include certain abnormal physiological factors. Abstracted they are as follows:

It is probably unwise to try orthoptic treatment in any patient who has an abnormal correspondence, as the tables show (Traver's Tables), that the longer the deviation persists the less likely is normal correspondence to be reëstablished. No treatment which does not include surgery had any beneficial effect upon the patients with abnormal correspondence. It appears that fusion training can improve a function already present but cannot usually develop the function. Cases with normal retinal correspondence who fail to improve under training, and with poor depth of fusion, have a relative poor chance of cure without surgery. It seems that even with good fusion there is a relatively poor chance of effecting a cure if the angle of squint is over 20 degrees. The advantages of early surgery, according to Travers, are: there will be an immediate improvement in the appearance of the child with all the attendant advantages. In these cases which have abnormal correspondence, there is far more chance of the development of normal correspondence and fusion when operation is undertaken early. The length of treatment is greatly shortened—usually by years. There is probably less likelihood of amblyopia developing—though of course this should be watched for—even after operation.

The disadvantages of late surgery are the following. The treatment is prolonged for years. There is more likelihood of amblyopia developing. In the cases with abnormal correspondence, there is less likelihood of the patient eventually obtaining normal binocular vision.

Lancaster calls our attention to the necessity for converting the deviations in degrees or prism diopters into millimeters. There are 360 degrees in the circumference of the eye. It has a circumference of 72 mm.; thus 1 mm., theoretically, equals 5 degrees of the arc. A degree of an arc is equal on the circumference of the sclera 10 prism diopters of deviation; or a convergent strabismus of 20 degrees must have the center of its cornea shifted 4 mm. In larger eyes 1 mm. will equal slightly less than 5 degrees, and in smaller eyes slightly more than 5 degrees. These rules and measurements apply only in the lesser degrees of deviation. In the greater degrees, the magnification of their contributing factors modifies the effect of these measurements and ratios. Lancaster calls attention to this in his discussion of the surgery of the ocular muscles and emphasizes these somewhat intangible and undeterminable effects. A high degree of convergent strabismus is augmented by the lateral rotation of the superior and inferior recti working together. The greater the degree of strabismus the more are

[1] Concomitant Squint. The Gifford Edmonds Prize in Ophthalmology: 1936, published by the British Journal of Ophthalmology.

the two recti mentioned acting as secondary internal rotators. In a similar way the check ligament and the difference between the anatomical relationship of the medial and lateral check ligaments all play important factors. Lancaster's rules for procedure are rather similar to Jameson's and Jackson's. Lancaster feels that it is impossible to reduce the problem to a simple rule, such as shortening or lengthening a rectus muscle a certain number of millimeters. He feels that a resection or recession of 4 mm. will probably move the eye 2 mm. if nothing is done to the antagonist.

Too often in muscle surgery, the operator disregards vertical anomalies. Reference has been made to this in 3, under Hyperphoria, Chart, Table 2. White and Brown[1] made a study of 11,600 persons in the hope of gaining some definite evidence as to the frequency of occurrence of the condition producing vertical anomalies and the effect of one condition on the other. Of this group, 1955 showed some anomaly of the motor muscles as judged by Duane's normals, and of these 36.6 per cent had an accompanying vertical anomaly. Convergence excess alone or complicated with divergence insufficiency was found in 16.6 per cent, with a vertical deviation in 39.8 per cent. Divergence insufficiency alone or complicated by a secondary convergence excess was found in 2.5 per cent, with a vertical deviation in 59 per cent. Divergence excess alone or complicated by a secondary convergence insufficiency was found in 7.5 per cent, with a vertical deviation in 59.9 per cent. Convergence insufficiency with a secondary divergence excess was found in 2.8 per cent, with a vertical deviation in 40 per cent. It is no wonder that White feels that many of the poor results from surgical treatment either of overcorrection or undercorrection are the result almost without exception of a vertical imbalance either not considered surgically, or not discovered diagnostically. The conclusions of White and Brown follow:

In uncomplicated convergence excess with either a lower or a higher degree of hypermetropia, a double recession will give a most satisfactory result. However, when a vertical imbalance is present, the same amount of recession for an equal amount of lateral squint may result occasionally in undercorrection but more frequently in overcorrection, about as much as the original squint. This result may be delayed or it may develop immediately after operation.

In uncomplicated divergence excess with a normal convergence near point, a conservative recession of one or of both external rectus muscles gives a good result. In the presence of a vertical imbalance, there may be an undercorrection, but much more probably a marked overcorrection.

In convergence insufficiency with secondary divergence excess, or when the divergence excess is primary, one can judge the operative results accurately when there is no vertical imbalance. But in the presence of a complicating hypertropia, the same amount of recession or resection may result in a definite overcorrection, but much more probably there will be an undercorrection of the lateral deviation.

In general, when considering the directions for the two deviations, that is vertical and lateral, the greater of the two deviations should be corrected first, surgically. It is not wise to correct the two deviations simultaneously. When the degree of vertical deviation approaches closely to that degree of lateral deviation present, then the vertical deviation should be corrected first. This is especially important when the degree of vertical deviation varies in the lateral rotation. One can see this as an outstanding factor in congenital and acquired palsies of the superior rectus on one or the other side. If the surgery is carried out in this sequence, and

[1] Arch. Ophth., vol. 21, June, 1939.

an adequate interval of time permitted between the correction of the vertical and lateral deviations one will find almost universally that there has been a definite decrease in the amount of lateral deviation present following the correction of the vertical Figure 160 is an interesting study of such a situation. A illustrates the left hyperexotropia as a result of congenital defect of both superior oblique and inferior rectus on the left, that is the patient had no functioning depressors on the left. The right hand depressors were normal. B of Figure 160 shows a marked increase in the hypertropia with right lateral rotation. C of Figure 160 is the early postoperative correction of both vertical and spontaneous correction of the lateral deviation following a tenotomy of the inferior oblique and tendon transplants from the superior and inferior recti to the internal rectus. The schematic charts which follow are quite illuminating. Attention is called to the cross wires in each drawing to illustrate the anatomical center in the palpebral fissure. 1 is a drawing of the eyes in repose; 2, the eyes with the left fixing, the secondary deviation is quite manifest, 3, the position of the eyes in right lateral rotation; 4, the position of the eyes in left lateral rotation; 5, the eyes in downward gaze, 6, position of the eyes in direct upward gaze; 7, the eyes up and to the right, 8, the eyes up and to the left; 9, the position of the eyes following tenotomy of the inferior oblique but before the surgery was completed by the tendon transplants to the internal rectus.

The proper time for surgery, in concomitant strabismus, is an important question. There are many factors which modify the decision. Naturally it is assumed that a careful study has been made of the case. As Dunnington states,[1] the value of all non-operative measures should be weighed in each case, and an operation advised only when convinced that in surgical intervention lies the only relief Occasionally such a decision can be made at once. In rare instances, it may take a year or two, but once it is made there is no reason for further waiting. Duane, twenty-two years ago, stated that "to let a child go on because in a small percentage of cases the operation fails seems to be ill-advised timidity." There is no doubt that secondary muscle changes develop in eyes of squinters of long duration. Overactive muscles become hypertrophied, and the underactive ones stretch and become weakened. Since these muscle changes diminish the chances for success, the earlier one operates, the more favorable are conditions for an ultimate complete correction. Postoperative diplopia is less likely to arise in patients operated on at an early age, and furthermore, should it occur, it is much more readily overcome in early childhood than in later life. The value of orthoptic training following surgery is a well established fact. The younger the child, the more likely is it that that degree of fusion which the child had at the time of surgery, can be utilized most advantageously in obtaining the best possible results.

Tenotomies which are partial, in that they include only a portion of the cross surface of the muscle, are of no value. Unwanted rotational effects may occur (especially in considering partial tenotomies of an inferior oblique over-action), and if a degree of deviation is present which needs surgery, a minimal recession of the entire tendon at the stump is the logical procedure. Tenotomy of the internal rectus, the superior rectus, and of the inferior rectus is never to be recommended. The lost convergence power connected with a tenotomy of the internal rectus can result in a secondary

[1] Arch. Ophth., vol. 10, October, 1933.

divergence of the eyeball giving a paralytic type of strabismus. Surgical procedures upon the superior and the inferior recti are always a matter of attention to fine details. Figure 127 illustrates the close and usual propinquity which exists between the superior and inferior recti, the external rectus and the superior and inferior oblique muscles. Recessions, tuckings, and advancements are procedures which can be controlled at all times. A tenotomy which has any appreciable value must have a complete detachment of the insertion of the muscle from the sclera. While there are no check ligaments on the superior and inferior recti comparable to those of the internal and external recti, still Tenon's capsule cannot be considered as an adequate anchorage for limiting the degree of possible posterior displacement. Tenotomy of the external rectus is occasionally indicated. The lateral check ligament will not pull the muscle so decidedly toward the lateral wall of the orbit; hence, divergence insufficiency will not develop. A recession should be done instead in practically all instances; it is such a simple procedure that it seems unwise to substitute for it another procedure

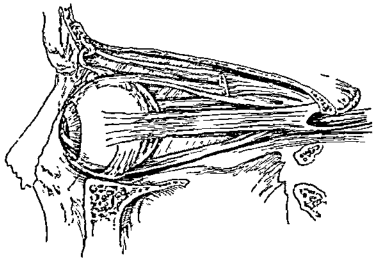


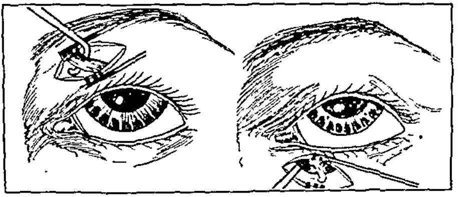
FIG. 127.—The close relationship which exists between the ocular muscles as seen laterally.

not equally satisfactory. Divergent strabismus from a paralysis of the internal rectus is really the only procedure wherein a tenotomy (of the external rectus) is justifiable.

Tenotomy.—The eyeball is moved nasalward and the conjunctiva incised vertically, in a concave manner, parallel to the curve of the external canthus, and 6 to 8 mm. from it. After the conjunctiva has been incised and the superficial layers of the fascia dissected free from the conjunctiva, a small muscle hook is placed under the inferior or the superior border of the muscle through the fascia to identify its position. This is immediately withdrawn and a snip made through Tenon's capsule at that place, uncovering the sclera. The hook is then reintroduced, passed under the muscle, and rotated slightly, so that the tip of the hook bulges the overlying capsule on the opposite margin of the muscle. A second snip is made here through the capsule and a larger hook reintroduced from that side lifting the muscle clear from the sclera with the fascial sheath still undisturbed. Without further dissection, the muscle belly and tendon are raised slightly from the

sclera and the tendon insertion cut from the sclera with sharp scissors. One should be careful that all the fibers have been cut and that there are no deeper posterior attachments to the sclera on the under surface of the muscle. In this way minimum dissection and trauma of and to the capsule has taken place. The conjunctiva is then closed with a running black silk No. 1, twisted suture, untied, and the free ends of the suture allowed to project from the conjunctiva.

Tenotomy of the inferior oblique is a sound surgical procedure. It is always indicated in the hyperphorias and the hypertropias which develop because of a paralysis of the contralateral superior rectus. The muscle is reached by an incision through the lower lid, or through the depth of the inferior cul-de-sac, at the junction of the inner and middle thirds, paralleling the rim of the orbit and immediately above it. When through the lid, the orbicularis fibers are separated and an incision made through the superficial fascia of the orbit. The tendon can be reached and delivered into the wound by a small muscle hook passed into this wound with the heel of the hook *away from* the nose, the hook being directed upward and slightly



A *B*

Fig. 128.—Tenotomy of *A*, the superior and *B*, the inferior oblique

inward. The tendon is readily identified when delivered There may be some prolapse of orbital fat. This is of no concern. A complete tenotomy (or myoectomy) is done and the wound closed in two layers, the fascia with No. 3-0 plain catgut, and the skin with an intradermic dermol suture (Fig. 128, *B*). If one feels it necessary to limit the subsequent excursions of the eyeball, the cut tendon of the oblique distal to the point of the tenotomy, can be anchored to the orbital rim with No. 3-0 catgut suture. This would act as a check ligament preventing any overaction downwards, as a result perhaps of the superior oblique. Such a precaution should be considered in the lesser degrees of hypophoria accompanying a paralysis or paresis of the contralateral superior rectus. (The word hypophoria is used here though the eye upon which the tenotomy is being done is directed upward as compared to the hypophoria in the contralateral eye resulting there from the paralysis of the superior rectus.)

Tenotomy of the superior oblique is a similar procedure with rather limited indications. In this the surgery is indicated because of the hyperphoria present as the result of the infrequent paralysis of an inferior rectus muscle in the eye contralateral to that upon which the superior oblique is

to be tenotomized. The eye with the overacting superior oblique muscle would have its visual axis directed downward as compared to the hyperphoria of the eye on the paralyzed side. In these paralytic conditions of the superior and the inferior recti, the basic hypo- or hyperphoria is exaggerated in the lateral rotations. When directed to the side of the paralyzed muscle, by the lateral rotations, the contralateral oblique muscles are now in a position for maximum elevation and depression, while the superior and the inferior recti yoked with the obliques are now also in a position wherein maximum vertical deviation will occur as a result of the paralysis of one or the other.

To tenotomize the superior oblique, an incision 1½ to 2 cm. is made in the orbital palpebral fold just below the rim of the bony orbit. The incision is carried through the tissues of the lid and the fascia until the bony margin has been uncovered. It is wise then to introduce small, self-retaining retractors. A hook is placed in the outer extremity of the incision, introduced with its heel toward the temple, directed somewhat posteriorly under the rim of the orbit and almost vertical to the plane of the face. As the hook is passed down toward the depth of the orbit, the handle is depressed toward the temple with the heel posterior. The hook should engage the tendon during this maneuver slightly behind the trochlea, the resistance from the tendon can be felt, and one can see the cornea moving down and out. With the tendon held on the hook, sufficient blunt dissection is carried out to free the tendon from the surrounding fat and fascia. It is then cut between the hook and the trochlea (Fig. 128, A). As soon as it has been cut the hook will release itself, and the cornea will move upward and outward. Hæmostasis should be completed, and as soon as the wound is

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LEGEND FOR FIG. 129

FIG. 129.—*A*, mild overaction of the left inferior oblique muscle right lateral rotation, with marked overaction of right inferior oblique muscle in left lateral rotation. *B*, similar situation with both eyes to the front, pupillary reflexes center; middle illustration; eyes to the left, overshooting right inferior oblique, underaction left superior rectus; lower picture, limitation of upward rotation on right, overshooting left inferior oblique. *C*, (*a*) schematic sketch of upper illustration *B*; (*b*) schematic sketch of torsion effect; O.D. increased inferior oblique elevation with gradually increased extorsion from overacting inferior rectus muscle (patient has paresis of right superior rectus. O.S. plus cyclophoria from extorsion of inferior oblique with depression of eye, the result of paralysis of the superior rectus on the left, and an overacting inferior rectus (patient has a paralysis of left superior rectus muscle); (*c*) schematic illustration of lower illustration of *B*. O.D minus cyclophoria, superior and inferior effects, somewhat unbalanced. Upward rotation somewhat limited from paretic superior rectus, minus cyclophoria due to overaction of intorting superior oblique muscle. O.S. marked overaction of inferior oblique muscle, with marked plus cyclophoria from overacting inferior rectus muscle. *D*, angles plotted to illustrate the bilateral plus cyclophoria. O.D. 27.5 degrees from the vertical. O.S. 17 degrees from the vertical. The sum of the 2+ cyclophorias results in 44.5 degrees of displacement, one vertical axis from the other in left lateral rotation. *E*, the analysis of angles as seen in the lowest illustration of *B*. (See sketches (*c*) of *C*.) The minus cyclophoria of O D. is 21 degrees. The marked plus cyclophoria of O.S. is 50 degrees. The sum of the minus cyclophoria O.D. and plus cyclophoria O.S. results in a difference of 29 degrees between the vertical axes of the two eyes in right lateral rotation. *F*, sketch illustrating Listing's law. O.D. and O.S. have moved from eyes front to eyes up and to the left. Straight dotted line illustrates the path of shortest distance between eyes front and the new position of corneæ. Curved dotted line upward illustrates the path of Listing's curve. Lower curve illustrates the pathway through which fovea travels in reaching its new position The inclination of the two corneæ in their new position illustrates true torsion as viewed and estimated in the line of the visual axis. False torsion would be that apparent additional inclination of the visual axes seen if this inclination of the axes would be viewed and estimated looking directly at the patient and not in the line of the changed visual axes.

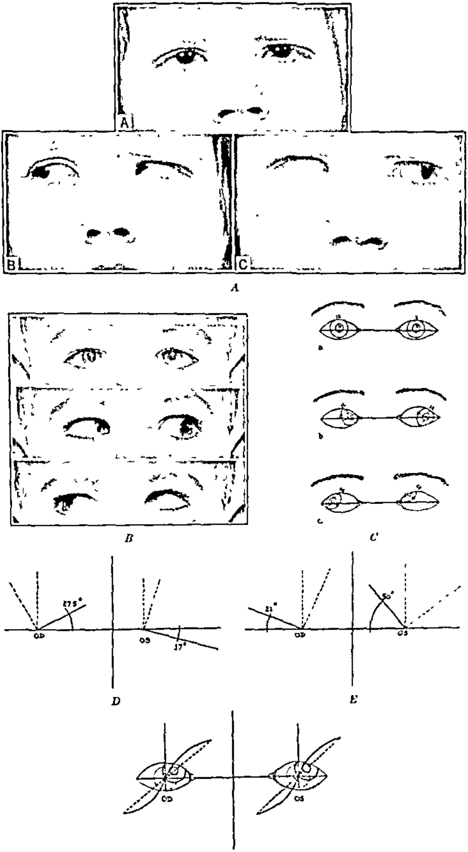

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FIG. 129

quite dry, the fascia of the orbital septum is closed with interrupted No. 3-0 plain catgut sutures. The lid may be closed with interrupted silk sutures or with an intradermic dermol suture.

An overacting superior oblique muscle, while not a common condition, may be as Hughs and Bogart state[1] the cause of extreme discomfort to the patient. It is probably always responsible for torticollis, though all cases of torticollis are not always the result of an overacting superior oblique muscle. (See Fig. 129.) In some of the lesser degrees of this condition the conjugate yolk muscle, that is the inferior rectus of the opposite eye, may be advanced to minimize the effect of the overacting superior oblique. In most of the cases, however, recession of the trochlea is a sounder procedure, and it makes unnecessary any lengthening operation upon the tendon of the superior oblique muscle itself.

Tenotomy of the superior oblique should never be done except under most extraordinary circumstances. (As Lienfelder pointed out the superior oblique muscle seems to be the pacemaker in many of the comitant binocular movements of the eye.)

The technique of Hughs and Bogart is as follows: "A transverse incision is made through the skin parallel to and over the orbital rim in the region of the superior orbital notch. This incision is carried through the skin and the superficial fascia exposing the periosteum over the orbital rim. This periosteum is incised and undermined with a periosteal elevator along the roof of the orbit for a distance of 2.5 cm. backwards from the anterior rim. Those parallel incisions are made on each side of the superior orbital notch about 1 cm. apart and carried deeply about 1.5 cm. These incisions are made on each side of the trochlea which is located by palpation. This periosteum with the trochlea attached is simply pushed backward into the orbit. Only the skin wound needs to be closed. A pressure dressing is applied to maintain the retro-displacement of the trochlea and is continued for four days."

Recessions.—Jameson's surgery, as applied to recessions, has been a valuable addition to muscle surgery. The author,[2] in 1924, spoke of the controlled tenotomy used in Lindner's strabismus operation, as preventing a later contralateral deviation due to posterior slipping or non-attachment of the cut end of the muscle. By means of the suture the operator allows as much muscle relaxation as is wanted to augment the rotation required and obtained through the advancement. In 1922, Jameson first presented his correction of squint by muscle recession with scleral sutures.[3] This was further considered in 1925,[4] and in 1931,[5] considerably augmented. Worth in his earlier surgery demonstrated that scleral suturing is accurate, is feasible, and is safe. The safety of the procedure simply rests upon the importance of the operator keeping the point of his needle always visible as it passes through the sclera, as Jameson says, "from its point of entrance to its exit." His observation is that a thin lamella of scleral fibers is translucent, while if a needle is passed through the entire thickness of the sclera, its course from entrance to exit would be invisible. There are certain rules connected with a recession which should be briefly given here. To achieve

[1] Am Jour Ophth, Series 3, vol. 25, No. 8, August, 1942
[2] Spaeth: Lindner Strabismus Operation, Arch Ophth., 53, 542, 1934.
[3] Arch Ophth., 51, 421, September, 1922.
[4] Trans Ophth Soc United Kingdom, 45, 405, 1931
[5] Arch Ophth, 6, 329 to 361, September, 1931

conservative work, Jameson feels that the equator should be the most posterior boundary for any recession. In the average sized eye the equator will be 5 mm. back of the insertion of the internal rectus and 2.5 mm. to 3 mm. back of the insertion of the external rectus. These are Evans' averages of the scleral measurements from Sweet, Weeks, Dickson, Salmon, Fuchs, Thompson, and Whitnall. In recession of the external rectus, especially when connected with a paralysis of the internal rectus, it may be permissible, in fact necessary, to reattach the resected external rectus tendon slightly more posterior than that measurement given above. Jameson's rules for the amount of recession are as follows:

(1) The equatorial position and the number of millimeters the operator desires to recede the muscle should be computed and measured and the points noted (2) The one principle never to be forgotten is that the muscle should never be receded behind the equator, the position which averages 5 mm from the insertion of the muscle on the internal side and 2.5 mm. on the external side, except under exceptional circumstances. (3) The actual degree of deviation, fixed, alternate or periodic, bears on the amount of recession. A greater amount would be necessary if the squint was fixed. (4) Marked correction of the deviation with glasses would lessen the amount of recession (5) The excursive power of the opposing muscle as ascertained by its ability to rotate to the canthi is a valuable indication If this is diminished, a greater amount of recession is indicated. If the opposing muscle has active rotary power, the amount of recession should be less. (6) The resistance after traction made by a strabismus hook before the muscle is severed is a valuable indication of strength and tension. (7) When exposure yields information that runs counter to the preoperative computation, one can close the wound and proceed on the opposing side. (8) Insufficient convergence with a remote near-point in internal deviation would decrease the recession or contraindicate it altogether An important point to remember is that a recession on the externi can be freely extended behind the equator if the interni are markedly insufficient, but should be conservative if the interni have active convergence power of 50 mm or less

Certainly most surgeons must agree with White, Jameson, Peter, and others, that in convergence excess a recession operation is logical, and in divergence weakness a shortening operation (as an advancement of the external rectus), is necessary. In a case of esophoria (or esotropia) from (or with) either convergence excess or divergence weakness, it would be unwise to perform the recession of the internal rectus in a divergence weakness or an advancement of the external rectus on a convergence excess Recessions have none of those distressing complications so commonly present when tenotomies were in vogue; widening of the palpebral fissure with or without exophthalmos, recession of the caruncle, loss of prism abducting power, and a contralateral deviation are unfortunately still seen Attention is again called to the maximum degree of recession possible, to the conservation of the capsule, to the correct visualization of the needle as it passes through the sclera, and to the conservation of the muscle tissue itself. The suture should be placed into the muscle as close to the tendon stump as is possible. Peter and White separately called attention to this A muscle clamp is not necessary, as it compels a more posterior introduction of the sutures than is otherwise needed, and further a certain percentage of the tendon must become necrotic. As a result of these two factors, a part of the results to be obtained through the recession is lost at the beginning Some further observation of Jameson's on recession follows:

(1) Recession (with the technique advocated) reduces the possibility of caruncle retraction, and minimizes secondary deviation; (2) the correction obtainable on external deviation is much more limited and usually requires a supplementary

advancement; (3) muscle function and rotation on the attenuated side is frequently restored by recession on the opposing side if the muscle is not paretic; (4) one of the most valuable aids to computation is the actual inspection and study of the muscle and the capsule after exposure; (5) the clinical amount of correction obtainable by recession in internal deviations, is greatly in excess of the mathematical amount as computed in degrees though in external deviations it is about the same as that computed mathematically; (6) conservative recession paves the way to safer and better advancements when used in conjunction with them; (7) a rule that seldom can be broken is that if a 5 mm. recession (internal) will not correct the deviation, the further corrective contribution must, of necessity, be brought about by advancement or recession on the opposing side; and (8) the single operation of recession gives a notably high return of correction as a sole procedure.

Relative to Jameson's procedure of a vertical capsulotomy, this seems unnecessary. The scleral suturing is the new point of contact, and further damage to the capsule if it does extend the effect of correction, does it to an unpredictable and indeterminable degree.

The technique for recession can be carried out according to Jameson's original plans or according to Peter's procedure. The latter of the two is that which the author has utilized. It will be given first. Local anesthesia by instillation and infiltration may be used, and general anesthesia, as in all muscle surgery, is very satisfactory. The conjunctiva is incised in a crescentic manner, with the concavity of the incision paralleling the limbus. When at the inner angle, the incision should lie just lateral to the caruncle, and at the outer angle, halfway between the normal insertion of the muscle and the extremes of the external angle cul-de-sac. The conjunctiva is incised and freed from the underlying fascia and from the insertion of the muscle on the sclera, to a point well beyond the position for the introduction of the muscle hook. A tiny slit is to be made in the capsule at a position judged to be the limit of either the upper or the lower edge of the muscle. A small strabismus hook is inserted under the muscle and rotated slightly so that the end of the hook elevates the capsule at the opposite edge of the muscle. This is incised, and a second hook placed through this incision, being certain that all of the tendon and muscle fibers are included on the hook. The capsule on both sides of the tendon sheath are then cleanly incised, and the muscle tendon itself bared of its capsular sheath. The two hooks are then separated as widely as is possible, the one *closely applied to the insertion, and the second retracted a certain distance* to cause a taut band of tendon between the two. The recession suture is then placed into the tendon; No. 3-0 plain to ten-day catgut is satisfactory, though twisted silk may be used. (If black silk is being used the ends of the suture must be brought out through the conjunctiva so that it can be subsequently removed.) White silk may be buried full-curved, and it will not show later. Number 4 to 6 full-curved eye needles can be used, or Jameson's own needle. The suture is whip-stitched through the edge of the tendon. Figure 130, 2, illustrates one method of insertion, and Figure 131, *C* and *D*, demonstrate Peter's use of a double arm whip-stitch suture. The first bite from within toward the edge of the muscle is taken as close to the proximal hook as it is possible to place it and still to leave it some tendon so that it can be cut, cleanly, from its insertion. Further, sufficient must be left to assure the operator that the suture will not slip later over the end of the cut tendon. The second bite lies close to the edge of the tendon, and slightly posterior to the site of the first bite. The two ends are

tightened, anchoring the suture and its spirals within the tendon, and narrowing its width the least bit at the same time. The hook more distal from the limbus can now be removed, the two ends of the suture drawn upwards,

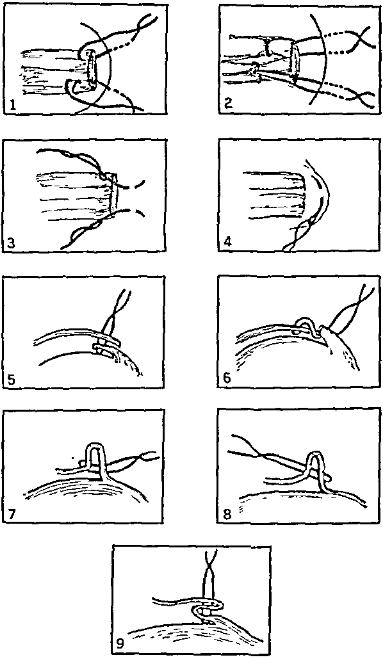


FIG. 130.—Lancaster's sketch to illustrate various sutures. (Lancaster's text abstracted.) 1, simple stitch through the muscle and conjunctiva—not satisfactory because it will cut out on slight strain; 2, whip-stitch which will not slip from the muscle; 3, mattress stitch through the muscles (this will hold securely if tied down as in (2), but will stand very little strain if tied loosely); 4, *scleral insertion; 5 and 6, mattress sutures from tendon to stump, 5, from* stump to tendon and 6, reversely from tendon to stump; 7, 8 and 9, tucking sutures. (9 requires a special tucker and is not recommended because of the multiple folds. In 7 and 9, the suture can be carried out through the conjunctiva and tied, thus making it removable.) (After Berens, courtesy of W. B. Saunders Company.)

vertically, and the tendon cut from its scleral insertion. Any adhesions from the muscle belly to the underlying sclera should be released and the scleral insertion of the sutures completed. The proper position for their insertion is selected, and they are then passed through the sclera, each an equal distance from the limbus, slightly farther apart than is the width of the cut end of the tendon. The needles as they are passed through the sclera should be directed up and in, and down and in, the least amount. The scleral lamellæ do not split as readily under such circumstances, and a firmer scleral attachment can be obtained. Each needle is then passed through the middle third of the tendon stump so that the sutures now converge. (Fig. 131, *B*.) The muscle is pulled up to the scleral attachments by the suture, the ends tied, and if catgut is used, cut short. If silk has been used, the ends must be passed through the limbal lip of the conjunctival wound and tied externally to the conjunctiva. The conjunctiva

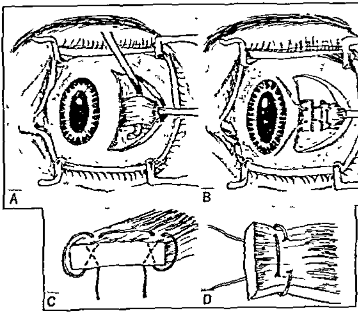


FIG 131.—Recession operation: *A*, the muscle lifted, *B*, sutures in position, and a schematic sketch to illustrate Peter's whip-stitch (*C*) in the cut end of the tendon (*D*).

is then closed with a running suture. A binocular dressing completes the operation. If a convergence excess defect is being corrected, atropine may be instilled. The first dressing should not be done under ordinary circumstances before the second postoperative day. The non-operated eye may be uncovered at that time, or later, depending upon conditions present. If an overcorrection seems imminent it is quite wise to uncover one eye. Under ordinary circumstances, however, the binocular dressing is best retained for about four postoperative days. The silk conjunctival suture can be removed on the fifth day, and if a silk recession suture has been used, it can be removed on the eighth day.

Rather often, recession is used as an adjunct to advancement. In the higher degrees of strabismus, it is wise to complete the recession first except for the final tying of the recession suture at the stump, for the advancement surgery is completed more easily. A danger of overcorrection, however, is

present when an advancement, with *recession of an antagonist*, is *done in* this order. Attention to this will permit one to utilize this order of attack, however, when necessary.

Jameson's technique[1] is as follows:

The conjunctival incision is vertical and is about 7 or 8 mm. in length following *the curve of the semilunar fold, and not in the usual place over the insertion of the* muscle. The field of operation is now exposed, the flap being dissected and turned over toward the cornea. The conjunctiva over the caruncle need not and should not be disturbed *for reasons outlined later. The capsule is now buttonholed* (with blunt-pointed Stevens' scissors, or with sharp scissors if the operator is adept) by pinching up a fold of capsule with tooth forceps. The point for buttonholing should be well behind *the insertion of the muscle (about 5 mm.), and about 3 mm. above* the muscle in the region of the equator, this for reasons explained later. The forceps should not let go the pinch of capsule until the strabismus hook has been inserted in the buttonhole and *has found its way under the muscle. If this is not* observed, the hole may be lost while the operator is looking for the strabismus hook. The scissors may precede the hook through the buttonhole, preparing a way for it and separating the trabeculæ from the globe. The muscle and capsular flap are now outlined. The muscle being undermined, the hook is swept under it well beyond the opposing border of the muscle, where it is again buttonholed at a point corresponding in distance from the muscle to the point primarily buttonholed. The muscle is now thoroughly undermined, and capsular incisions markedly diverging are regulated according to the amount of recession sometimes required behind the equator. These incisions to complete the flap are also carried from the point of entrance and exit of the strabismus hook to meet the muscle at the outlines of its *insertion. This will outline the flap to be receded. The female blade of muscle* forceps is now introduced beneath the muscle (from below in the right eye and from above in the left), if the interni are being receded, and the muscle is clamped and severed, care being taken not to snip the globe at this point under *insertion* where the sclera is of paper thinness. The sclera is now thoroughly exposed, the muscle separated from the sclera to the base of the flap, and the débris and blood are *sponged away. The sclera then appears white and glistening, and presents an* unobstructed field for the introduction of the scleral sutures. Small venous extravasations may be controlled by an epinephrine pad. Rarely does one have the *anomaly of venæ vorticosæ emanating from the region of the equator. They are* always visible and easily avoided in introduction of the needles. The measurements and graduation are now determined. The distance from the insertion of the muscle (presently to be described) that the operator desires to recede the muscle is measured in millimeters and the point is noted on the sclera. Three single armed sutures are provided. The first, the central one, is introduced from without the conjunctival lip nearest the caruncle; it then perforates the outer surface of the muscle at one point 5 mm. below the center and one point 5 mm. back of the end of the tendon. The needle then is passed through the muscle from the undersurface, *one point* 5 mm. above the center of the muscle, and brought out on the upper surface. The thread is looped around and behind the suture where it first perforated. This central suture is now made *to split the sclera, taking a 2 mm. bite, and being carried* forward it perforates, on its undersurface, the conjunctival flap adjacent to the cornea. The two remaining ring sutures pass in transit from the outer surface of *the caruncular conjunctiva, muscle end, sclera and conjunctival lip nearest* the cornea. Their perforations through the caruncular conjunctiva, sclera, end of the muscle and conjunctival lip adjacent to the cornea should be made sufficiently well *apart to insure a broad attachment of the muscle to the globe and* permit the closure of the extended primary conjunctival incision. They should be at least 3.5 mm. apart. The sutures are now carefully separated, the toilet of the operation completed and the muscle approximated to its new scleral attachment. The tying of the sutures firmly holds the muscle to its attachment and at the same time closes the conjunctival opening.

Lombardo has modified *Jameson's recession operation. He uses a single* double-armed suture, though with his modification a muscle clamp is also

[1] Arch. Ophth., 51, 441, 1922, and 6, 329, 1931.

necessary; hence a certain portion of the tendon is probably lost. After the muscle has been resected from the sclera, one of the needles is inserted into the scleral tissue at the site of the new attachment in a vertical manner across the horizontal meridian. The two needles are then passed through the muscle from its scleral surface, 2 mm. above and below the horizontal mid-line of the muscle. Each suture then is reintroduced into the muscle near the upper and the lower border. The needles are then inserted through the sclera, vertically, equal to the first scleral insertion about 5 to 6 mm. above and below the initial scleral bite. The muscle clamp is then released, and as the sutures are pulled up into place, the muscle is carried to its receded position and there anchored firmly to the sclera. If this suture is of No. 3-0 plain catgut, it can be tied, its ends cut short, and the conjunctiva closed with black silk.

The recession operation is a sound surgical procedure but it has limitations. They are no greater than those connected with any other type of muscle, and the danger of penetrating to the choroid with the needle should not occur in the hands of a capable operator. It is so, as Lancaster states, that eyes have been lost of panophthalmos following penetrating wounds by needles while operating on the muscle. This is not a deterrent to the operation, but it is a demand for attention to details and to skill in technique. Prangen[1] also uses catgut for scleral anchorage, but he uses two sutures instead of Jameson's three, and he also uses a muscle clamp. These sutures are introduced into the free end of the tendon in front of the muscle clamp instead of behind it.

Tucking.—A muscle tucking, more properly a tendon and/or muscle tucking, is a convenient method of shortening an ocular muscle without disturbing its original insertion. There are two types of tucking to be considered: that achieved by the assistance of some mechanical device known as a tucker; and second, the results obtained by Knapp's tendonal capsular advancement. The number of tuckers available is astonishing. Peter's modification of the Bishop tucker is wholly satisfactory. The curved foot plate follows the convexity of the sclera and as a result keeps the tendon equally divided on the two halves of the hook. The stem of the foot plate is sufficiently wide so that the sutures when placed are adequate for the shortening, and at the same time they do not complete a tenotomy of the muscle through the subsequent strangulation necrosis which must occur of those tendon fibers contained within the knot. Any tuck which subdivides the entire width of the tendon into two portions is dangerous, because of the possibility of a subsequent necrosis tenotomy. In general, tuckings are most readily done and give best results on (*a*) the external rectus; (*b*) the superior and inferior recti; and (*c*) the internal rectus. Several reports have been presented of a tucking of the tendon of the inferior oblique, but these results are not conclusive. Further, the effects of an underacting inferior oblique are best corrected upon its synergistic contralateral rectus, as has been discussed.

The conjunctival incision and exposure of the muscle are made as described under recessions. Tenon's capsule should be stripped from the muscle for tucking; though with advancements and resections, such stripping of the capsule is wrong. The hook of the open tucker is passed under the muscle, the strabismus hook removed, and a 4 mm. to 8 mm. loop of

[1] Trans. Am. Ophth. Soc., p. 280, 1934.

tendon raised upon the hook of the tucker, depending upon the degree of tucking necessary; this is also controlled by the tension of the muscle and the tendon as found at dissection. A tuck of 6 mm., without unusual tension upon the tendon (considering that the 12 mm. in linear length of the tendon enclosed, is not actual, but is increased by stretching) is the maximum to be done, under ordinary circumstances. This will give the greatest result which can be obtained from a tendon tucking and the statement can be used as the measurement criterion. Further, also, the muscle which is being operated upon modifies the amount of looping which can be obtained. It is not necessary to bare the tendon wholly of its enclosing sheath. Two chromic catgut sutures of No. 3-0, even 2-0, are passed in the angle between the heel and the stem of the tucker and tied with two single knots, one knot at a time, however. As Peter has said, "Unless this is done a firm knot will not be obtained, and this is most essential." Figure 132 shows diagrammatically the tucker in place and the proper and improper introduction of the sutures. As soon as the sutures are tied, the ends are cut short, the hook lowered so that it lies below the foot plate of the tucker, and the tucker is withdrawn. The tuck should then be inspected to be certain that the conjunctiva and contiguous capsule have not become entangled with the tuck; this if present, is freed, and the conjunctival wound closed with a running silk suture. The postoperative care is exactly the same as that prescribed for recessions. The postoperative reaction is normally more marked for a tucking than for recessions and advancements. Tucking without a tucker will be described shortly.

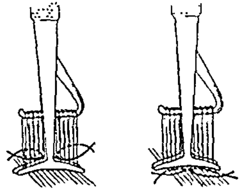


Fig. 132.—Tendon tucking with the Peter modification of the Bishop tucker. *A*, suture correctly placed, and *B*, incorrectly placed (Peter.)

The technique of Knapp's tendonal capsular advancement,[1] essentially a tuck, is a very satisfactory procedure. The conjunctiva is vertically incised over the insertion of the tendon, and undermined around the cornea to the vertical meridian. Tenon's capsule is opened with the scissors at the lower line of the insertion line of the tendon, a strabismus hook slipped beneath the tendon, and the capsule incised over the tip of the hook on the upper side of the tendon. The sutures are applied, one through the conjunctiva and the lower edge of the muscle, passing under the conjunctiva obliquely forward, then for 3 mm. through the outer layers of the sclera immediately before emerging on the conjunctiva near the vertical meridian. The second suture on the upper side is passed similar to the first. A third suture is passed through the conjunctiva and the middle of the muscle, under the hook, which during the application of all the sutures lifts the tendon, and thrusts through the middle of the tendon near its insertion, then through the superficial layers of the sclerotic to emerge on the conjunctiva near the cornea. The sutures are tied and the case dressed as with all tuckings. The result obtained is somewhat less than that possible through an ordinary

[1] Trans. Am. Ophth. Soc., 1886.

tuck, but it will account satisfactorily for 10 degrees of deviation when used alone, though more than this when used in combination with a recession.

A single folding or tucking operation, without a tucker, will give results about equal to this. It fits in very nicely for the least possible deviation which is to be surgically corrected; for hyperphoria, for convergence insufficiency, and for completing a case, when with an advancement, a slight additional amount of correction is needed. After the muscle has been bared, each end of a double-armed No. 3-0 ten-day catgut suture is whipstitched (Fig. 131, *D*) through an edge of the tendon and muscle 4 to 8 mm. behind its insertion, each end of the suture, similarly. The two ends are then carried under the muscle and through the sclera at its tendon attachment. The eye is rotated toward the muscle, the suture pulled up, and tied tightly. The conjunctiva is closed as before. This technique should give 8 to 10 degrees of correction.

In general, muscle tucking is the outgrowth of de Wecker's capsular advancement. There have been quite a few modifications of it, but usually the principles are the same. Contributors to this procedure have been Kalt,[1] Lagleyze,[2] Savage,[3] Todd,[4] and Foster.[5]

Cinch Operation.—O'Connor's advancement or cinch operation is, according to O'Connor, of special value in the phorias. Posey, 1921, and Chance, in 1922, performed similar operations to that described by O'Connor in 1931. The operation has enthusiastic advocates. The author feels that convalescence is somewhat longer, though the patient is, at least according to O'Connor's method of handling the case, postoperatively an early ambulatory case. The author has seen the threads inadvertently removed by the patient himself. The original technique (Fig. 133), quoting Lancaster, as it appears in Berens,[6] is abstracted somewhat as follows:

(1) Expose and isolate the tendon and muscle. (2) Separate the tendon and muscle into several equal strands from the insertion back toward the equator, a distance slightly greater than the amount of shortening desired. To do this, hold the tendon well spread out on a large muscle hook, divide it into two equal parts by a small longitudinal incision, extending this down the middle of the muscle, taking care not to cut across any muscle fibers, but only separating the fibers. This can be done with a small Stevens hook after the tendinous portion is divided with a knife, such as a knife needle. Each of the two parts into which the muscle and tendon have been split is now itself divided or split longitudinally in the same way into two strands. Thus one divides the tendon and muscle into four equal strands without having cut across any muscle fibers. In some cases it is better to divide the muscle and tendon into three equal strands by two longitudinal incisions instead of into four, for example, when the tendon and muscle are attenuated and dividing into four parts would make the strands too slender and easy to break. (3) A suture consisting of a number of threads of non-absorbable smooth suture material is threaded in a curved needle such as a tonsil needle, with its point cut off and smoothed, so as to avoid catching any fibers. A fine silk thread tied around the cable close to the needle holds the threads together. This cable is wound around one strand after another of the tendon in the following manner: The needle is introduced in the space between the first and second strands, is passed under and

[1] Soc d'ophth , 2 mars, 1891.
[2] Arch d'ophth , 12, 668, 1892
[3] Ophth Record, March, 1893
[4] Ophth. Record, 11, 73, 1902, and Ann. Ophth , October, 1904; also Jour. Am. Med Assn , January 7, 1905
[5] Versammlung der Niederl. Ophth. Gesellsch , December, 1901.
[6] Berens. The Eye and Its Diseases, W. B. Saunders Company, p. 1150, 1936.

around the first strand, emerging alongside the edge of the tendon. About half the length of the cable of threads is drawn through. Next, the needle is passed again around the same first strand of muscle. The second strand is now *encircled twice* in the same way, then the third, and the fourth.

The next step is *pulling the cable of threads taut. When this is done, the cable* becomes straight; instead of being wound around the strands of muscle the muscle *strands are wound around the cable of threads. This shortens the muscle.* The amount depends on (*a*) the size of the cable, that is, the number of threads compris*ing the cable;* (*b*) *the number of times* the cable has been looped around the muscle strands, and (*c*) the size of the muscle strands—the fewer and larger the strands into which the muscle is divided, the greater the shortening when the cable is pulled taut and the muscle wound around it. The loops of muscle should be gently pushed together forming a tuck. The tuck will now appear as seen in Figure 133 (*d*) When the conjunctival incision is closed the sheath of threads is buried. These are removed one at a time three weeks later under local anesthesia The amount of shortening which is obtained is about 2½ degrees for each strand of medium sized thread used in the cable. The operation may be combined at any time with a recession upon the antagonist.

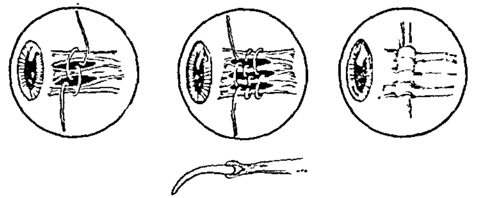


Fig 133.—The technique of the O'Connor cinch operation (Berens-Lancaster courtesy of W. B Saunders Company)

O'Connor feels that this operation is the ideal correction for pure convergence insufficiency. He is unwilling to agree with Bielschowsky that pure convergence insufficiency is solely of nervous origin and that (Bielschowsky) any good results from surgical intervention are due to the correction of an undisclosed exophoria. Anatomically, O'Connor bases his opinion upon his repeated findings of long and frail internal rectus muscle tendons in these cases. He states:[1]

The good effect of shortening a tendon, therefore, is to restore the normal proportion between the length of the tendinous and that of the contractile part of the muscle, thus increasing the response from the available nerve impulse It is only in those patients who have strong internal rectus muscles with short tendons that I suspect a nervous origin to be the sole cause, and in these, as would be expected, the operative results are less certain. Building up the nerve impulse to its best constitutes the non-operative treatment and should be carried out in all cases, operation is out of order except as a last resort. I (O'Connor) can see no excuse for a refusal, on purely theoretical grounds, to give a patient the chance for a cure by means of surgical intervention, provided, as has already been stated, that it has been conclusively established that the insufficiency is the cause of the symptoms This is one condition in which it is fair to expect help from exercises, but it has been my experience that failure is the rule My cinch shortening gives a positive and accurately graduated effect which can be reduced by removing one or more shorten-

[1] Arch. Ophth., 14, 987, December, 1935

ers if the immediate esophoria is too great. The tendon is not cut, nor is the normal insertion changed. Had I (O'Connor) nothing more accurate than ordinary tucks and advancements, I (O'Connor) also should hesitate to operate in cases of pure insufficiency.

Resections and Advancements.—Resections which shorten a muscle by removing a portion of its tendon will be considered under advancements, in that practically all advancements have as an essential part of their technique a resection of that portion of the tendon which lies within the jaws of the advancement forceps.

In general, the use of an advancement without resection is limited There is one definite indication, however; it applies to the reattachment of an internal rectus wherein divergence strabismus or convergence insufficiency is present because of a former tenotomy of the internal rectus. The technique is similar to that outlined for a recession, except that the muscle must be reattached in front of its former faulty position; in most instances anterior to the stump of its original and normal scleral insertion. The dissection for uncovering the muscle and its tendon will oftentimes be difficult. The former surgery has caused adhesions between the sclera, the conjunctiva, and the capsule, and one must dissect slowly and deliberately. Retraction of the tendon of the internal rectus may be so extensive that it will be found in close approximation to the inner wall of the orbit. The muscle should be lifted on a hook and freed wholly from its fascial sheath. The hooks are inserted, as under recessions, and the double-armed silk or catgut suture whip-stitched through the tendon. The tendon is then cut free from its faulty position and attached to the sclera by two scleral bites placed immediately anterior to the normal position of the tendon stump. If silk is being used, these sutures are continued through the conjunctiva and tied externally, while catgut sutures can be tied directly upon the sclera, their ends cut short, and then covered subsequently with the conjunctival suture. Peter, in reattachment advancements, uses a second scleral bite, the first two lying rather close together in front of the former tendon stump, these being passed obliquely through the sclera, as is proper with all scleral sutures, and the second somewhat closer to the limbus and more widely separated. The silk suture that he uses then continues out through the conjunctiva at the limbal lip of the wound. In tying the suture, the bight of suture between the two scleral points is first pulled up anchoring the muscle in its new position, and after the two ends are drawn upon, a knot tied. Considering the scar and the adhesions which are always found in these cases, it is wise to utilize this additional scleral anchorage if the sclera cannot be cleaned of adhesions. When catgut is used for the advancement, one may use a single scleral attachment only. The conjunctiva is then closed with an untied suture as previously described.

Noyes[1] recommended a pure advancement wherein the tendon is cut at a distance from its insertion varying in accordance with the degree of squint, after a single mattress suture had been placed from below through the tendon one-quarter of its width from the upper and lower edges of the muscle. The distal end of the cut tendon is brought up beneath the proximal portion of the tendon stump and the two sewn together with the mattress suture. The suture is buried and the conjunctiva closed. The postoperative care is that covered under advancements.

[1] Trans. Am. Ophth. Soc., 1874.

Simple Resections.—In most instances as said, resections and advancements are combined. Reese, however, has a very satisfactory simple resection operation. The correction obtained results wholly from that amount of tendon which has been removed; in that the new insertion of the operated muscle is at the tendon stump. Figure 134, *B*, illustrates this technique. His procedure[1] is as follows:

A vertical incision 1 cm. in length is made through the conjunctiva about 6 mm. from the limbus. At the upper and lower borders of the muscle Tenon's capsule is incised with the scissors and the strabismus hook is passed under the tendon. The conjunctiva is dissected back to the canthus and the muscle is freed from the lateral insertions. The Prince forceps are introduced, and the muscle alone is clamped at right angles to its fibers. The muscle is then severed about 2 mm. from its attachment to the sclera. The sutures are inserted in the following manner. A heavy double-armed suture is first taken and one needle of it is passed through the muscle from within outward at the junction of the middle and upper third of the muscle, 4 mm. behind the forceps, and brought out through the edge of the conjunctiva The second needle is passed in a similar fashion at the junction of the middle and lower third of the muscle. The finer sutures are passed through the edge of the conjunctiva (posterior lip), one in the upper and one in the lower border of the muscle, from without inward; slightly posterior to the middle suture. The muscle is now severed about 2 mm. behind the blades of the forceps The two needles of the middle suture are passed through the scleral stump, 2 mm from each other and brought out through the conjunctiva. The needles of the finer sutures are passed through the upper and lower edge of the scleral attachment including the conjunctiva also The sutures are now tied, the middle one first. After operation both eyes are bandaged for three days, after which the finer sutures may be removed and the unoperated eye left open. The operated eye should be bandaged and the middle suture is left in place for ten days.

Figure 134, *B*, shows this same thing diagrammatically; *A*, is Haab's single-stitch advancement.

Prangen[2] presented a pure resection by the utilization of two gold plates, used as splints to hold the cut ends of the tendon together. The tendon is exposed and grasped with a muscle forceps including the conjunctiva, and then cut. A double-armed suture is then threaded through one gold plate; the two ends of this suture pass through the conjunctiva and muscle posterior to the forceps, and through the stump of the muscle and out through the conjunctiva. A second gold plate is threaded upon these sutures and the two ends firmly tied. He uses a twisted black silk and by including a second (white) marker suture in the loop of the advancement suture, the subsequent removal of these plates is greatly facilitated.

Advancements with Resections.—Verhoeff's, Prince's and Worth's operations are the three to be considered here. The details of the Prince advancement and resection are shown in Figure 134, *C*. A thread to be used as a pulley is passed tangentially through the conjunctiva and episcleral tissues near the limbus. The tendon is uncovered, and the conjunctiva and the tendon are grasped with the muscle forceps. The two needles of a double-armed suture are passed from below, upward through these structures. A loop is thus placed on the underside of the tendon. One of the free ends of this double-armed stitch is laid across the pulley-stitch, as shown in Figure 131 and this is then tied over it. Traction is made on the double-armed suture until the tendon lies in its new position. The free ends are then tied, one being under the other, over the pulley-stitch. That portion of

[1] Török and Grout: Ophthalmic Surgery, Lea & Febiger, 1913.
[2] Trans Am. Ophth Soc., p 281, 1934

tendon, of conjunctiva and of capsule within the jaws of the forceps is cut away with the scissors.

Verhoeff's resection with advancement is shown in Figure 134, *D* and *E*. In his operation the tendon is grasped with a Prince's forceps and detached

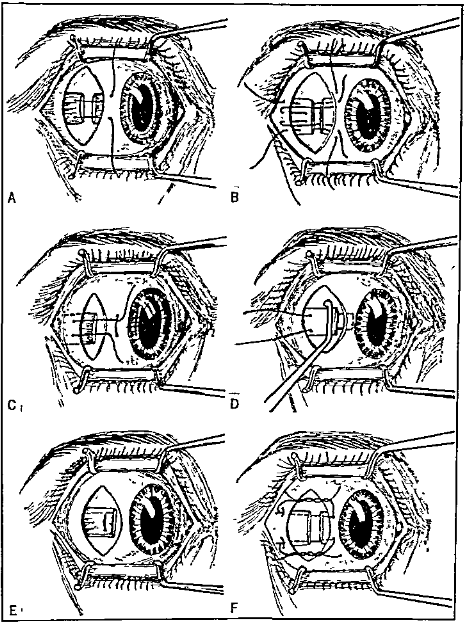


Fig 134 —Muscle advancements *A*, the Haab single suture advancement; *B*, the Reese resection, *C*, the Prince operation, *D* and *E*, Verhoeff's resection and advancement; *F*, the sutures for the Worth advancement and resection

from its scleral insertion as described under recession operations. The clamp with the tendon is then folded back and the sclera exposed beneath it. A double-armed silk suture is passed through the sclera 1 mm. from the cornea and for 6 mm. to 8 mm. through the superficial layers in a direction at right angles to the axis of the tendon. (See vertical dotted lines in the

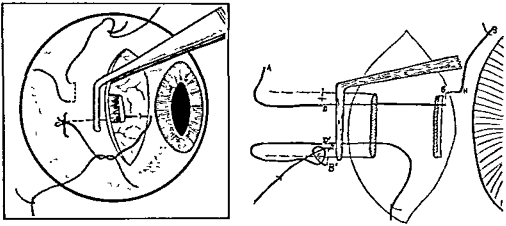
drawing.) Each needle is again introduced at its point of exit and carried for a short distance through the sclera in a horizontal direction. Both ends of the suture passed in this way are then carried through the advanced tendon from beneath upwards and there tied securely. The muscle enclosed within the forceps is resected, and the suture cut short and buried. Either No. 3-0 ten-day catgut, or a white silk braided suture should be used.

Worth's advancement with resection has proven eminently satisfactory. His technique as outlined by himself is as follows:[1]

The surgeon, standing behind the patient's head, grasps the conjunctiva with a toothed forceps, while, with the scissors, he makes a curved vertical incision through it rather more than ½ inch long. The convexity of the incision is close to the corneal margin. A similar incision is made through the capsule of Tenon. The conjunctiva and capsule then retract, or, if necessary, they are pushed back so as to expose the insertion of the tendon. The lateral expansion, well below the tendon, is snipped through with scissors. One blade of the advancement forceps is now entered below the lower margin of the tendon, and passed under the tendon after the manner of a tenotomy hook. When it is accurately in place the other blade of the forceps is attached, being superficial to all the structures, so that tendon, capsule of Tenon, and conjunctiva are all firmly held together with their relations undisturbed, except for the retraction of the membranes. The tendon is now divided with the scissors at its insertion into the sclerotic. The part of the sclerotic near the cornea which is intended for the new insertion of the advanced muscle is now carefully cleared with toothed forceps of all loose tissue; for, unless the end of the muscle is held accurately in contact with bare sclerotic, there will be no firm union. The advancement forceps holding the tendon, capsule, and conjunctiva can now easily be lifted up so as to get a good view of the underside of the muscle. It is very important to avoid any vertical or torsional displacement of the eye after the operation. In order to mark the proper alignment of the muscle during the subsequent manipulation, a suture is passed from the conjunctival surface (posterior lip) through the center of the muscle to its under surface. It is carried under the advancement forceps to the corneal margin, where it is inserted into the sclerotic in exact alignment with the old insertion of the tendon. It is merely a marking suture, and is not intended to bear any tension, though, when tied at the end of the operation, it helps to keep the edges of the wound in accurate apposition. Each needle and suture before being inserted is drawn through a fold of lint in which is a little sterile petrolatum. This makes the hitched suture easier to remove. One of the needles is passed inwards at A′ through conjunctiva, capsule, and muscle. It is then again passed through muscle, capsule, and conjunctiva, and brought out at B′. The bight of the thread thus encloses a width of about 2 mm. near the upper edge of the muscle, together with capsule and conjunctiva. The ends of the thread from A′ and B′ are then crossed over, making a half-hitch at C (see Fig. 135, *B*). The end bearing the needle is then entered at D and passed through conjunctiva, capsule, and muscle, and then carried beneath the lower blade of the advancement forceps, out of the wound, and stuck into a piece of gauze which as been placed on the patient's forehead to receive it. The suture A, B, etc., at the lower margin of the muscle is then similarly dealt with, its needle also being brought out of the wound and stuck into the gauze. The anterior parts of the muscle and capsule and conjunctiva are then removed by cutting them through with scissors behind where they are grasped by the advancement forceps. The longitudinal position on the muscle of the loops A, B, C, and A′, B′, C′, and the amount of tissue removed, vary according to the degree of rotation required. If only a very small effect is required, perhaps no tissue at all may be removed. The sutures on the muscle are placed 2 mm. behind the cut end, in order that there shall be no tension on the extreme end of the muscle while union is taking place. The next stage in the operation, the insertion of the two main sutures into the sclerotic at G and G′, is one that requires great judgment and delicacy of touch. Take one of the needles in the holder, leaving about ¼ inch exposed. With the fixation forceps take a firm hold of the globe at the site of the old insertion. Lay the back of the needle on the sclerotic exactly in line with the position of the suture

[1] Worth, Claud: Squint, 6th ed., P. Blakiston's Son & Co., p. 157

in the muscle (in other words, keep the suture parallel with the "marking suture") and about $\frac{1}{8}$ inch more from the corneal margin, according to the degree of effect required. Press the point of the needle backwards slightly so as to dimple the sclerotic a little. Then push it onwards so that it traverses at least half the thickness of the sclerotic, but taking the greatest care not to pierce the whole thickness. The superficial extent of the insertion of the suture is about $\frac{1}{4}$ inch. A fresh hold of the needle is now taken with the holder, and the needle is pushed through a little farther, until it can be grasped again with the holder just below the point and pulled through. The other main suture is similarly dealt with. No verbal directions can be given for gauging the depth. One judges by sight and touch. One's tactile sense also warns one of an abnormal thinness of sclerotic, which is occasionally, though rarely, met with. (AUTHOR: Before tying, the stump must be thoroughly removed from the sclera.) The surgeon ties each suture at H and H', with the first hitch of "the surgeon's knot," gradually tightening it as he manipulates the anterior end of the muscle with forceps into the desired position. Care must be taken that the anterior end of the muscle be neither inverted nor everted. The tension of the sutures is adjusted and each knot completed by a second hitch. These two sutures bear all the weight. The marking suture is now tied. If there be any gaps in the membranes above or below the holding sutures, they are closed with additional fine sutures. The immediate effect is the permanent result. No overcorrection, therefore, is necessary.



A B

FIG 135.—*A*, The original technique as presented (Courtesy of John Bale Sons and Curnow, Ltd.). *B*, Sketch to illustrate details of the suture.

Figure 135, after his drawing, illustrates the technique. There are certain modifications of Peter's to this original technique which are recommended. The middle suture should be of white silk, and a No. 1 twisted is best. The two lateral sutures should be of No. 1 black braided silk. Bone wax impregnation of the sutures is preferred to petrolatum. Instead of a half-hitch between the loops of the lateral sutures, it seems better to tie these in a simple square knot. As the sutures are being tied, it assists decidedly if an assistant will rotate the eyeball toward the tendon being advanced. And lastly, before the sutures are tied, the sclera should be cleansed rather thoroughly of that portion of the stump which is still adherent.

While the sutures are being introduced to the sclera, the stump furnishes a convenient and strong hold with forces to facilitate their introduction. It should, therefore, be removed after and not before the insertion of the scleral sutures. A needle holder which grasps the needle firmly is necessary for the introduction of the sutures through the sclera. The ordinary

mosquito type of hæmostatic forceps is also inadequate. Worth's needles need not be used. A No. 4 full-curved eye needle, flat in cross-section, upon the convexity, and self-threading, is as satisfactory and perhaps even preferable. A binocular dressing should complete the operation. Atropinization is used if indicated (see above). As with all ocular muscle operations, it is wise to anoint the lids lightly with 1 to 1000 or 3000 bichloride of mercury ointment. The first dressing is done forty-eight hours later. If convalescence is uneventful, dressings thereafter are sufficient upon alternate days. Ordinarily, the operated eye may be uncovered upon the fifth or sixth day. The sutures may be removed on the fourteenth day There will be no difficulty in cutting and removing the central white silk suture; oftentimes it is dropped out before this. A drop of holocain or cocain is first instilled, one of the cut ends of the suture is grasped, and both loops cut with sharp scissors, first, the loop which ties the conjunctiva and muscle together, and second, the loop which passes through the sclera. (The longer the scleral bite, taken at the time of the surgery, the more readily will one be able to find this.)

Recession of the Obliques.—(See page 236.) Under certain circumstances occasions will present themselves wherein overaction, or even normal but uncontrolled action of a superior or an inferior oblique is to be corrected but a tenotomy is undesirable. Such an instance would be a situation wherein the hyperphoria from an overacting inferior oblique is to be corrected, but a tenotomy of that muscle, because of the degree present would give (in the instance being considered) an overcorrection. Similarly in hypophoria, considering the superior oblique, a minimal defect is to be corrected. Wheeler and White separately have both demonstrated the feasibility and ease of receding these muscles upon the sclera to obviate the overcorrection resulting from a tenotomy. The external rectus is temporarily tenotomized, the eyeball rotated strongly nasalward, and plain catgut sutures placed in the superior and inferior margins of the muscle to be receded. It is then detached from the sclera with sharp scissors, the operator being careful not to perforate the sclera, the tendon is permitted to slip back the desired amount, and it is then held there by the two catgut sutures. These are inserted into the superficial sclera at a point external to their original insertion, and as they are tied, a sufficiently large loop is permitted in each of the two sutures to allow the retraction desired. They are tied in this manner, and their ends cut short. Plain catgut must be used; 6-0 is adequate, and the sclera here also should not be perforated in introducing the needle. The scleral insertion of the sutures should be so placed that they will continue the arc of contact of the oblique muscle as it swings about the globe. This is important, for if the sutures are placed too far anteriorly or too far posteriorly in the sclera unwanted torsional effects will result postoperatively, and the elevator or depressor action of a muscle will be, in part, lost as well. The extramacular retina lies immediately anterior to the sclera at this site, and a perforation might result in a para-central scotoma from traumatic choroiditis.

Advancement of the Oblique Muscle.—Bannister, in his Extrinsic Ocular Muscles in Health and Disease,[1] stated that in paralysis of either the superior or the inferior oblique, limiting of the operation to the affected eye is impracticable from anatomical considerations, and the respective con-

[1] Am. Jour. Physiol. Optics, January to October, 1931.

tralateral muscles must be set back by tenotomy to secure relief from the diplopia, by inducing a deviation of a similar character in the case of the sound eye. Fusion then becomes attainable.

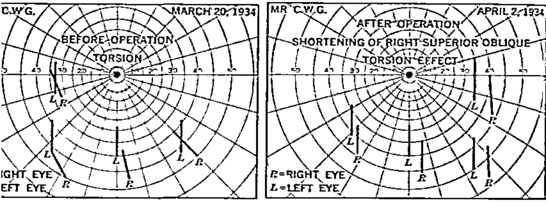


FIG. 136

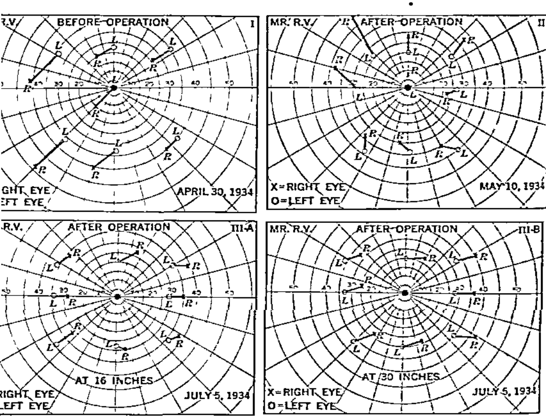


FIG. 137

FIGS 136 and 137.—Charts showing the effects of oblique muscle surgery.
FIG. 136 —Shows the correction of torsion.
FIG 137.—Shows little effect on torsion but considerable depression showing the need for overcorrection (As Wheeler stated)

Wheeler, in contradiction of this, demonstrated the feasibility of operating on the obliques. He stated there was no specific rule for the amount of advancement required, but that considerable immediate overcorrection is

necessary. For instance, if torsion effect is desired, the new insertion should be made farther forward than the original insertion. If, on the other hand, further elevation or depression is desired, as in hypo- or hyperphoria respectively, the original axis of the tendon from pulley to insertion with the superior oblique, from origin to insertion with the inferior oblique, should be present. The more elevation and depression and abduction function desired, the more backward should the new insertion be carried. Charts of Figures 136 and 137 illustrate the end-results; Figure 136 shows an almost complete correction of a torsion defect, while Figure 137 shows little effect on the torsion but considerable upon depression. In this case, as he stated, the original direction of the tendon was preserved in the advancement, but the different plottings show the need of overcorrection. In speaking of an advancement of an inferior oblique, Wheeler finds this procedure especially useful in the hypophoria accompanying ptosis of the globe, and in such cases it may be combined with an advancement of the superior rectus. His technique for advancement of the superior oblique and of the inferior oblique as presented in his original article is as follows:[1]

> The operation is performed under general anesthesia. The eyeball is turned well down by means of a suture attached to the sclera just above the cornea. The conjunctiva is incised in the upper fornix, and dissected so as to expose the insertion of the superior rectus. A suture is passed through the superior rectus tendon near its insertion, and the tendon is cut between the suture and the insertion. The superior rectus is then allowed to retract and is separated from the underlying superior oblique tendon. A strabismus hook is slipped under the somewhat frail superior oblique, and a double needled suture of fine catgut or silk is made to loop the middle third of the tendon several millimeters from the insertion. The needles are then carried into the superficial sclera temporal-ward from the original insertion. During the maneuver the eye should be held downward and inward as far as possible. When the double needled suture is tied, the superior oblique is advanced in an amount to correspond to the distance from the points of entry of the needles in the tendon to the points of their entry to the sclera. It does not matter whether or not the tendon is cut off near the original insertion. There seems to be no advantage in cutting the tendon. After the superior oblique is fastened to the sclera the superior rectus should be sutured back in place, and the conjunctival wound closed with fine silk sutures. This operation is performed under either infiltration or general anesthesia. On several occasions, during a number of years, I (Wheeler) have attempted to shorten the inferior oblique by tucking the muscle just behind its anterior attachment, and at times I (Wheeler) have attached the tuck to the periosteum at the orbital margin. In some instances the results have been disappointing. The technique here presented is satisfactory. A skin incision about 2 cm in length is made along the orbital margin with the anterior attachment of the inferior oblique at about its center. The dissection is carried through the tarsoorbital fascia into the orbit and the inferior oblique is exposed. The dissection is carried also downward for exposure of the periosteum 1 cm or more below the orbital margin. While the muscle is held on a strabismus hook, two fine chromic catgut sutures are passed through the tendon near its anterior attachment. The tendon is cut free at its attachment and carried over the orbital margin. It is advanced as much as is necessary, and then secured to the periosteum on the facial surface of the superior maxillary bone by means of the catgut sutures (000) as shown in Figure 141. The skin wound is then closed with the silk sutures.

These operations are indicated in the vertical phorias and the torsional defects individual and peculiar to pareses of the obliques, either the superior or the inferior.

[1] Am. Jour. Ophth., 18:3, January, 1935

PARALYTIC STRABISMUS

Ocular Motor Dynamics and Rotational Factors Relative to the Disturbances in the Ocular Motor Rotations as a Result of Individual Paralyses.— In considering the ocular muscles and the result of individual ocular motor paralyses it is important to know, without any hesitancy, the primary and secondary functions of the extra-ocular muscles. Regardless of the underlying purpose for the surgery in non-concomitant strabismus there are three factors important in technique: (1) to enhance disturbed functions; (2) to minimize exaggerated functions; and (3) to minimize or to nullify the overaction of a contralateral synergist. These are basic. Figure 138 is a side view of the projected action of the ocular muscles.[1] In this projection the various axes of rotation, as a result of the individual muscles is illustrated. Figure 139, also from Duke-Elder, shows Tschermak's modification of

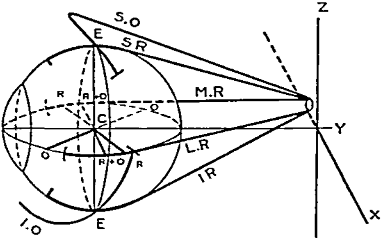


Fig. 138.—Side view schematic, projected, showing the action of the ocular muscles in various planes (Duke Elder, Discussion of Muscle Planes, vol. 1, p 603.) *X.Y.Z.*, the directional axes of Fick, *S R*, *I.R*, *M.R.*, *L.R.*, superior, inferior, medial, and lateral recti. *S O.*, *I O.*, superior and inferior oblique muscles. The medial and lateral recti rotate the globe around the axis, *E E*, passing through the center of rotation *C*. The superior and inferior recti rotate the globe around the axis *R R*. The obliques rotate the globe around the axis *O O*. When these are combined a movement around *R* plus *O* in Listing's plane results.

Hering's figure in which the uncomplicated rotation, adduction or abduction, is plotted as produced by the superior and the inferior recti and the obliques, while dark terminal cross-lines representing the horizontal meridian of the eye indicate the rolling produced by the latter four muscles. Figure 140 is a diagram taken from Duane's original thesis representing comprehensively the action of the various muscle movements throughout the field of fixation. It illustrates the maximum elevation and depression action in the various directions of the anterior posterior axis of the globe, the degree of torsion, and the degree of internal and external rotation. *C* represents the fixation point in the primary position; *D, E, O*, its position when the eye is abducted 18, 25, and 45 degrees; and *B, A, P*, when adducted 20, 45, and 50 degrees. At *A* the superior rectus acts as a simple adductor and rotates the eye along AA_1. The lines BB_1, CC_1, DD_1, EE_1, represent the direction and amount of movement produced by the superior rectus for

[1] Duke-Elder: Text-Book of Ophthalmology, vol. 1, second printing, p. 605.

these respective positions. Similarly AA_2, BB_2, CC_2, DD_2, EE_2 represent the direction and amount of movement produced by the inferior oblique from these positions. The lines AA_3, BB_3, CC_3, DD_3, EE_3 represent the movement produced by the superior rectus and inferior oblique acting

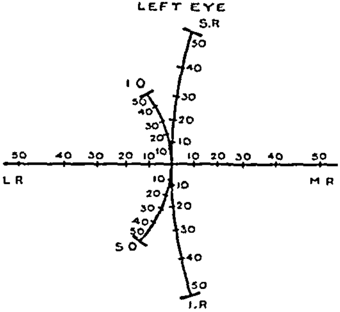


FIG. 139.—Tschermak's modification of Hering's figure to illustrate the maximum vertical action of the obliques and of the superior and inferior recti It also shows the direction of and degree of wheel-like torsion of each, and the horizontal action of the medial and lateral recti (After Duke-Elder.)

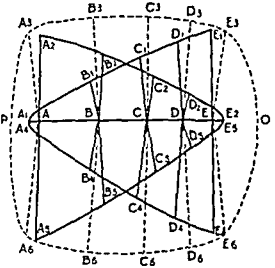


FIG. 140 —Duane's graph of maximum action muscle See text for detailed analysis (From Duane's original essay on Oculomotor Disturbances)

together. The lines A_1, B_1, C_1, D_1, E_1 and A_2, B_2, C_2, D_2, E_2 therefore represent the limits of the fields of action of the superior rectus and inferior oblique respectively acting separately, and A_3, B_3, C_3, D_3, E_3 of the two acting together. Similarly A_4, B_4, C_4, D_4, E_4 and A_5, B_5, C_5, D_5, E_5 repre-

resent the limits of action of the inferior rectus and superior oblique; while the outer dotted lines represent the limit of the field of fixation.

Quoting from Duke-Elder,[1] "The diagram brings out several important facts. The vertical action of the superior and inferior recti is nil in adduction and increases progressively as a position of abduction (E) is reached. The converse is true in the case of the obliques, and the resultant of the two acting together is approximately the same. Moreover, the lateral action exerted by these muscles is in inverse relation to their vertical action. Thus in adduction the superior and inferior recti have no vertical component but merely adduct the eye further (AA_1), while in abduction they have a vertical component only (EE_1). It follows that in adduction the superior rectus and inferior obliques acting together will carry the eye, not straight upwards but upwards and inwards, the adducting action of the rectus being unopposed by any abducting action of the obliques. Similarly the slope of the line BB_1 denotes the amount of rolling which occurs with upward movement from the position B: it is only when movements commence from the primary position C that no rolling is evident (CC_1)."

These three graphs illustrate the ocular motor dynamics of basic importance in discussing the actions of the various antagonists and synergists when modified by an oculomotor paralysis.

In discussing paralysis of the superior rectus muscle White[2] gave as rules for the surgery of this condition:

> (*a*) strengthening the paretic muscle by advancement, resection, or tucking; (*b*) weakening a secondary deviation by tenotomy or recession of the overacting muscle, the associate antagonist (yoke muscle) of the paretic muscle; (*c*) lessening the secondary contracture of a direct antagonist by tenotomy or recession of this muscle.

To lessen muscle action a recession is preferred, as White states, except in the case of an inferior oblique, where a tenectomy or a myectomy, depending on the structures at the site of the operation, has been found more advantageous. In general, a simple tenotomy is not adequate. In all cases where the deviation is greater than 5 degrees (in which a simple tenotomy may be used) it is best to resect from ½ cm. to 1 cm. of the muscle (inferior oblique) leaving the sheath of Tenon's capsule intact. Duane advised (White) inferior oblique tenotomy in cases of superior oblique paralysis when the secondary contracture of the inferior oblique was marked. Inferior oblique tenotomy is also indicated in the retraction syndrome with a disfiguring upshoot. Paralysis of the superior rectus muscle is not really uncommon. In general, its surgical correction depends upon nullifying the action of the contralateral inferior oblique with its spasm contractures and overshooting. White subdivides these cases into several groups.

The first of these, in which the hyperphoria in the primary position is less than 5 degrees, in which the secondary deviation is not marked, and those in which the paralysis is bilateral in equal amount, are to be treated by correcting prisms with the more prismatic correction on the greater hyperphoric eye. Group two includes those cases wherein the secondary deviation is not excessive, but in which a tenectomy of the inferior oblique usually is indicated. In this the hyperphoria or hypertropia in the primary

[1] Text-Book of Ophthalmology, vol. 1, second printing, p. 610.
[2] Trans. Am. Ophth. Soc., 31, 560, 1933.

position increases rapidly in the field of the paretic superior rectus. When the action of each superior rectus is about equal and fairly good, or with a marked deviation of the inferior oblique, a double inferior oblique tenectomy gives very satisfactory results. If the double hyperphoria is not equal, but a difference of more than 10 prism diopters exists, the inferior oblique of the greater hyperphoric eye is operated upon first, and the *superior rectus of the same eye may be receded later.* Group three includes those of progressive seriousness wherein the hyperphoria is up to 10 prism diopters in the field of the paretic superior rectus. In these, the inferior oblique should be operated upon first, and if an undercorrection occurs

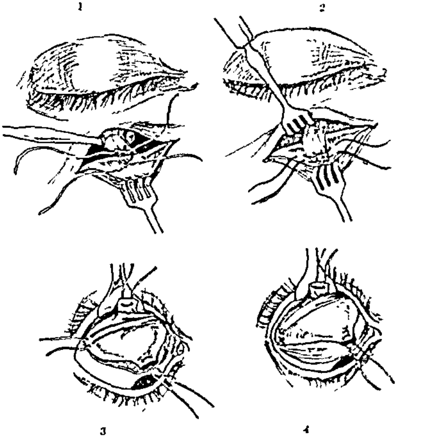


FIG. 141.—1 and 2, the technique for shortening the inferior oblique, 3 and 4 that for shortening the superior oblique. In 3, the superior rectus has been temporarily resected, and 4, shows *the scleral insertion for the shortening sutures* (Wheeler.)

which remains stationary after three months, and further, which increases in the field of the inferior rectus, this muscle, the direct antagonist of the paretic superior rectus, *should be receded in the hypophoric eye.* Bilateral cases in this group are treated in the same manner as are those mentioned in group two. When the double hyperphoria is equal in amount, this may be all that is required, but when it is unequal, the inferior rectus of the hypophoric eye is receded. *Group four includes cases of superior rectus* paralysis associated with an esophoria, or esotropia, or an exophoria or exotropia, and may be unilateral or bilateral. In many of these instances, the vertical deviation is probably the cause for the lateral deviation. Gen-

erally the vertical deviation should be corrected first by an inferior oblique tenectomy, and the lateral deviation corrected laterally as indicated. Divergence excess does not occur in those instances as often as a convergence insufficiency, but in either case the vertical deviation should be first corrected either by prisms or by operation, before attacking the lateral deviation present. Group five comprises those rare instances wherein a superior rectus paralysis is combined with an inferior oblique paralysis in the same eye. These individuals have a strong backward tilt of the head, and the procedure to be followed is a resection of the superior rectus with tucking of the inferior oblique of the same eye. It may be necessary to recede the inferior rectus also of this eye, and if ptosis accompanies the case, to correct this as well.

White's contraindications to surgery upon the inferior oblique muscle are as follows:

(a) in those cases where the deviation is slight and produces no symptoms; (b) where, with a small deviation, the use of prisms or the frosting of a portion of one or both lenses will relieve symptoms; (c) in cases of marked deviation with aversion to binocular single vision; (d) in cases of superior oblique paralysis in which the inferior oblique contracture is not marked. In this condition a recession of the contralateral inferior rectus seems to be the indicated procedure; (e) in some cases of marked bilateral superior rectus paralysis with bilateral inferior oblique spasm the operation is contraindicated or should be confined to but one side. (AUTHOR: In such instances, as with a RH of 40° plus, a tuck may be taken in the superior oblique muscle first.) The reason for this is that, with both superior recti quite paralyzed, a bilateral inferior oblique tenectomy would leave no muscle to elevate the eyes. This has resulted in a backward tilt of the head and a disfiguring contracture of the frontalis muscle; and, (f) age in itself is no contraindication. The youngest patient in this series was operated upon at the age of eighteen months, whereas the oldest patient to be operated upon was sixty-six years of age.

A, *B*, and *C* of Figure 129 show us a typical example of marked inferior oblique overaction. *A* shows the eyes in repose and when directed to the front. In right lateral rotation there is a slight overshooting of the left eye upward as a result of some superior-rectus palsy on the right. In left lateral rotation the overshooting of the right eye upward is a pronounced characteristic of the case. It is so marked here that at first examination the diagnosis was thought to be a congenital palsy of the right superior oblique itself. There was, however, no limitation of downward rotation in the right eye when in the position of left lateral rotation, this showing a good functioning superior oblique muscle. The overshooting only appeared in binocular gaze to the left, hence, cleanly diagnostic of the overaction of the right eyed-left hand elevator as a result of a paresis (or paralysis) of the left eye-left hand elevator (conjugate yoke muscle), thus, in this case, a paralysis of the left superior rectus. Duane's table of choice as quoted by Dunnington[1] is as follows:

TABLE 3.—ILLUSTRATING CHOICE OF OPERATION IN MUSCLE PARALYSIS (DUANE)

Affected muscle	Operation of choice
Superior rectus	Tenotomy inferior oblique opposite eye
Inferior rectus	Resection of affected muscle
Superior oblique	Tenotomy inferior oblique same eye or recession inferior rectus opposite eye
Inferior oblique	Tenotomy superior rectus opposite eye

[1] Am. Jour. Ophth., Series 3, vol 14, November, 1931.

Kremer[1] and van der Hoeve,[2] both (though separately) called attention to the presence of torticollis in long-standing paralysis of the trochlear nerve and emphasized the necessity for surgery in these instances. Because, as Bielschowsky[3] states, the vertical divergence is at its maximum upon adduction of the involved eye (hence the torticollis), without showing the indication of a paralysis on raising and lowering the line of vision, the surgery of the inferior rectus can be done in such a way that the lasting operative insufficiency of this muscle equalizes the paralytic weakness of the superior oblique of the other eye. *His technique is to make a horizontal* incision of the conjunctiva of the eyeball 6 mm. below the lower border of the cornea in front of the point of insertion of the rectus inferior. The tendon is loosened, held with a clamp forceps, carefully freed from the fascia holding it to the sclera and conjunctiva, and then detached from the eyeball. A needle with a double thread is drawn through the tendon from the inner side next the eyeball to the outer side, then through a point on the conjunctiva of the eyeball which is *fixed at a greater or less distance from the site of the incision according to the effect desired.* As a rule the needle is passed through at the point of transition between the bulbar conjunctiva and the fornix conjunctiva, no tight knots are tied, but only a loose loop, with the threads allowed to hang down over the lower lid. Suture of the conjunctival wound is indispensable in order to prevent any sinking of the lower lid, with a very unsightly exposure of the sclera below the cornea. At the close of the operation, motility of the eye operated upon and its coöperation with the other eye must be tested.

As a result of Jackson's experience, which he presented in 1903, in utilizing the superior rectus as a transplant for a paralysis of the superior oblique, he recommended in 1923[4] the utilization of the superior oblique for third nerve paralysis. *At the time he stated that the superior oblique* could be taken up by any method described for tenotomy of that muscle, with the tendon isolated and divided far enough from the pulley or from the eyeball to furnish a sufficient length of tendon for this purpose. This principle will be discussed later.

The Jaw-winking Syndrome.—This syndrome will be discussed later under ptosis, but it is relevant here in that its surgery, in so far as the ocular muscles are concerned, *is exactly similar to that necessary for the* correction of those changes connected with the misdirection of regenerating third nerve fibers, see Figures 142 and 143.

The Misdirection of Regenerating Third Nerve Fibers.—Walsh and King[5] were the first to call attention to the importance of the pseudo-Graefe syndrome, *i. e.*, the misdirection of regenerating the third nerve fibers as a sign of intra-cranial saccular aneurysms. It is also a not uncom*mon finding in* some other intra-cranial situations. The surgery of this condition is exactly necessary as that for the Jaw-winking Syndrome. The latter of the two is an acquired pathological state, the former is a congenital affair.

In this condition, during the process of regeneration of the nerves, fibers destined for various muscles find their way instead into other muscles

[1] Klin. Monatsbl. f. Augenh., Stuttgart, 69, 640, December 12, 1922.
[2] Ibid., 69, 620, December 12, 1922.
[3] Ibid., 69, 611, December 12, 1922.
[4] Am. Jour. Ophth., 6, 117, February, 1923.
[5] Ocular Signs of Intracranial Saccular Aneurysms, Arch. Ophth., 26, 1, January, 1942.

The most common confusion is that the fibers which should terminate in the inferior rectus find their way into the levator. Similarly, fibers for the

FIG 142 —Marcus-Gunn phenomenon (See section on Congenital Ptosis.) With fibrosis of all the ocular muscles save the levators, and with complete absence of all ocular motility (*A*) in repose, *B*, lids lifted to show strabismus fixus, both eyes down and to the left. (Kindness of Dr J S Shipman)

FIG. 143.—Same case as Figure 142. *A*, strong elevation of both upper lids with forcible closure of the jaws; *B*, a similar action but somewhat less so, with a wide opening of the lower jaw. (Kindness of Dr J. S. Shipman)

internal rectus will also, at times, terminate in the levator. As a result in downward gaze or with internal rotation the otherwise ptotic upper lid lifts strongly to fall again into ptosis as these above muscles cease their

contraction. One case was found (this also had been mentioned by Walsh) wherein fibers destined normally for the *inferior rectus, terminated in the* sphincter pupillæ, that is, with downward gaze the otherwise fixed pupil contracted slightly, to dilate again with the return again to the forward gaze.

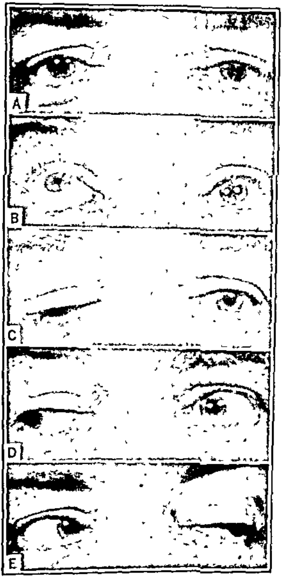
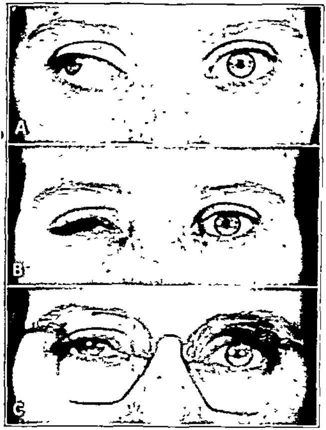
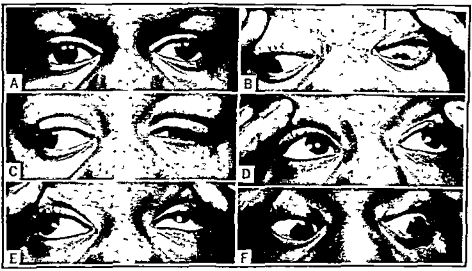


FIG. 114.—Pseudo-Graefe syndrome. Ptosis in left lateral rotation, strong elevation of the upper lid in right lateral rotation, less so in downward rotation; the residual paralysis of the left superior rectus remains unchanged.

In these instances the surgery first necessary is the correction of the residual lateral deviation; second, to dissect the entire levator free from the tarsal plate and the superior cul-de-sac, forming there by a complete paralytic form of ptosis; third, the correction of this paralytic ptosis by the use *of orbicularis* fibers into the occipito-frontalis, that is the Reese technique; and fourth, surgery to the superior and inferior recti on the



A



B

FIG. 145*A*.—Divergent strabismus fixus with ptosis and exophthalmos (apparently after an incomplete subtotal congenital 3d nerve palsy): *A*, prior to any surgery; *B*, following the muscle surgery; *C*, following correction for the ptosis. (This latter condition increased definitely after the muscle surgery.)

FIG. 145*B*.—Classical retraction syndrome. (It is interesting, see text, how the various characteristics outlined in Aebli's discussion are illustrated in this case.)

opposite eye to limit their arc of contact—hence to limit their vertical excursion so that these will correspond more nearly with those pathologically limited excursions in the opposite paralyzed eye. (See Fig. 144.)

Strabismus Fixus.—*This condition, divergent or convergent, follows* rarely after an external rectus paralysis. The antagonist becomes fibrosed and is converted into a rigid non-elastic band adherent to Tenon's capsule, and to the capsule check ligaments.

Divergent.—The surgery demands the *removal* of all contracted muscles, with a wide resection and advancement of the paralyzed atrophic muscles. Figure 145 is such a case. Motion is not to be expected after this surgery, but cosmetically, the case is tremendously improved Microscopic examination of the contracted antagonist shows clearly the fibrosis responsible for the fixed strabismus. The essential cause for this condition is not known

Convergent.—In ordinary cases of convergent strabismus fixus, one can see the defect at operation. Assuming an old, long-standing paralysis of the external rectus with the eye held firmly and constantly in paralytic esotropia, the internal rectus in many of such instances, will be thick, very much shortened, very fleshy, firm, and taut, the typical appearance of the muscle in a retraction syndrome. This exception is usually present, however. In the latter, retraction syndrome, it is usually of a normal length, while in strabismus fixus, as White said, the antagonist becomes *a short rudimentary band entirely fibrous, and holding the eye firmly* in the nasal field. White[1] in discussing congenital paralysis of the sixth nerve, spoke of strabismus fixus as follows, though abstracted: In strabismus fixus, the eye is firmly fixed at the inner canthus, the head is *rotated to the right, or the left, depending upon which eye is chosen for* fixing. It may be difficult, and often impossible, to make a definite diagnosis without exploring the muscles. At operation, it is often necessary to go well back to engage the hypertrophied fibrous muscle on a muscle hook, and when the muscle hook is so engaged, *no amount of reasonable* traction will move the eye from its strabotic position. A case was reported in which the globe was ruptured during such an attempt As the externi are usually normal, a complete tenotomy would allow the normal externus to abduct the eye now abnormal, resulting *in a later divergent strabismus. To guard against this*, one should do a generous recession of the fibrosed internus, even to well behind the equator, using the fibrosed internus as a stay to prevent abnormal external rotation.

Retraction Syndrome.—In this condition, *there* is a marked limitation of both internal and external rotations, narrowing of the palpebral fissure in internal rotation (even in the primary position), and retraction of the globe in external rotation In addition, up and down shooting of the eye may occur in external rotation as well. The degree of severity in each instance depends upon the amount of fibrous tissue deposited in the muscles, that is, the degree of degeneration in the muscle tissue itself. (See Fig 145.) The conditions may be bilateral or unilateral. It is probably the result of fibrosis following the orbital invasion of extra-periaxial mesoderm interfering with the normal development of the extra-ocular muscles as these arise from the periaxial mesoderm.

[1] Trans Am Ac Ophth and Otol., 1935.

According to Aebli,[1] the outstanding peculiarities of this syndrome are the following:

1. Complete or, less often, partial absence of abduction in the affected eye.
2. Partial, rarely complete, deficiency of adduction in the affected eye.
3. Retraction of the globe in adduction, rarely in abduction.
4. Narrowing of palpebral fissure in adduction with tendency to widen in abduction. Various explanations have been offered and theories discussed.
5. An oblique movement of affected eye either up and in or down and in when impulse to adduct is exercised.
6. Remote near point of convergence.

White's test for diagnosis is quite convincing. The tips of the index and middle fingers of one hand are placed one on each lower orbital margin just opposite the position of the inferior oblique, making light equal pressure with each finger. The patient is asked to look to the right and the left. The affected eye will be felt to retract from the lid in adduction, while the sound eye will approximate the lid throughout the excursion. In bilateral cases, each in turn will retract. With this test retraction can be demonstrated in most cases, and may be a deciding point in some cases which appear first as simple external paralysis.

The surgery in these cases depends upon the presence or absence of abduction, and the degree of narrowing of the palpebral fissure. Recession of the internis with weak external rotation is sound surgery. Advancement of the levator is to be done in those cases with a marked narrowing of the palpebral fissure. Tenotomy of the external rectus may be necessary because of marked fibrosis of this muscle. Tenotomy of the inferior oblique is usually indicated. A tenotomy of the superior rectus may be seriously considered at times. Considering that the underlying pathology is probably congenital, and is a fibrosis of one muscle (as the external rectus) an external rectus tenotomy may be necessary to release the eyeball for adequate internal rotation without its simultaneous retraction.

Surgical Principles, Paralytic Strabismus

The correction of paralytic strabismus is not always a simple surgical procedure. The text has already covered the application of inferior and superior oblique tenotomies in the correction of the hyperphoria for contralateral superior rectus and inferior rectus palsies. Reversely, paralyses of the obliques themselves are to be treated by a recession upon the contralateral superior or inferior rectus which are synergistic with them. Figure 142 is a diagrammatic sketch showing the primary and laterally rotated positions of the eyes in the various common forms of paralysis of an elevator or of a depressor. In each instance, the overshooting of the non-paralyzed and the gross vertical deviation of the paralyzed eye, as shown in the lateral deviations, emphasize the surgical essentials illustrated. Figure 150 is a beautiful demonstration of primary and secondary deviation from a combined internal and superior recti paralysis of the left eye. A case with paralysis of the external rectus can oftentimes be made

[1] Anomalies of the Extra Ocular Muscles, Section on Instruction, Am. Acad. Ophth. and Otol., 1941.

orthophoric for near, by a wide advancement, with resection, of the external rectus and its capsule, combined with a maximum recession of the internal rectus. Figure 147 is a case of bilateral sixth nerve birth palsy, prior to surgery, which, following recession of the internal recti, alone, was orthophoric with better than fair external rotation as a later development. Figure 148 illustrates the ocular torticollis of a left superior rectus con-

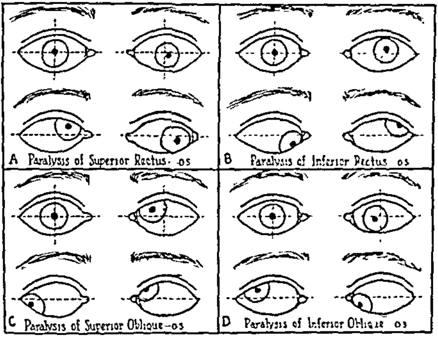


FIG. 146.—Diagrammatic drawings to illustrate the primary deviations and the overshooting in various elevator and depressor paralyses. (See text.)

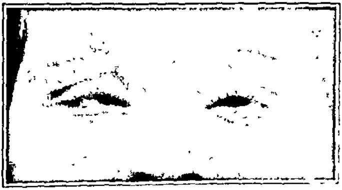


FIG. 147.—Bilateral birth trauma external rectus palsy.

genital palsy as the patient tips her head to escape the rotational effects of the extorted left eye by matching the two corneal meridians into parallelism. Figure 148 illustrates this in diagram.

Figure 149 (courtesy of Dunnington and Berke) is an unusual type of oculomotor palsy, connected with and from chronic orbital myositis.[1]

[1] Arch Ophthal., vol 30 No. 4 October, 1943.

Their surgery consisted of the dissection and removal of the lesion, "a solid, fibrous, smooth, firm, dark bluish mass below the globe, which seemed to be attached to all sides of the inferior rectus muscles." No normal tissue of the inferior rectus could be found, and at the conclusion of their operation almost all the tumor mass and the *inferior rectus muscle* had to be removed together. Following the surgery, the patient was able to move his right eye moderately from side to side, but not below the horizontal plane. The condition is rightly included herein as a form of paralytic strabismus.

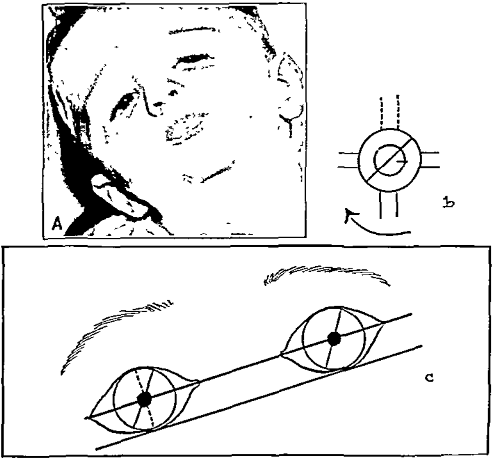


FIG 148.—Ocular torticollis from and with paralysis of the left superior rectus *A*, child with torticollis. *B* illustrates the plus cyclophoria due to overaction of the extorter, in this instance the inferior rectus on the left; *C*, dotted line O.D is perpendicular to the inclined plane, the parallel equally inclined solid lines illustrate the adjustment by tilting of the patient's head to intort the right eye by right head tipping so that the vertical meridian of this eye will be inclined to the same angle as that seen in the plus cyclophoria of the left eye with its paretic superior rectus. A somewhat similar situation to Figure 129. In that instance analyzed to illustrate the pathological torsion (cyclophoria), the result of paralyses of the vertical muscles.

It is within reason to consider simultaneous advancement of both superior and inferior recti, combined with recession of the internal rectus and an advancement of the external rectus for acquired abducens paralysis. A simple recession of the internal rectus is the opposite extreme for surgery in these instances, applicable especially in a case of congenital or birth trauma paralysis.

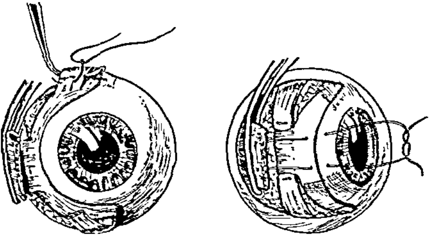
Tendon transplants, according to O'Connor's technique for the classical Hummelsheim operation from the superior and inferior recti, have repeatedly been of great assistance. The results obtained are not due to the

FIG. 149.—Exophthalmus, with marked hypotropia from chronic orbital myositis (see text). *A*, preoperative, looking straight ahead with the left eye fixing. *B*, postoperative, looking straight ahead with both eyes fixing. Surgery (see text). (Dunnington and Berke, courtesy of Arch. Ophth.)

FIG. 150.—Primary and secondary deviations. *A*, secondary deviation of a left-sided internal rectus, superior rectus, and levator *which develops when fixation is forced in the left* eye; *B*, the primary deviation.

development of new and vicarious functions, but (*a*) because of a more effective lateral rotation of the eyeball, (*b*) and its maintenance in that position by reason of the recession of the secondarily contracted antagonist, (*c*) the advancement and resection of the paralyzed tendon, and (*d*) un-

doubtedly assisted by the massive adhesions which must occur in the fascia over and about the transplanted tendons as a result of the extensive surgery there. Wiener[1] apparently obtained similar results by a complete sectioning of the paralyzed external rectus, 15 mm. from its attachment and splitting this adherent portion of the muscle into two halves, suturing the upper of the two to the superior rectus tendon and the lower of the two to the inferior rectus tendon. It is rather likely that a similar "stay" effect is obtained as a result of his modification (Figs. 151 and 152). The operation is best applied to a paralyzed external rectus, next in value to the internal rectus, and last to the inferior rectus. Paralysis of the superior rectus is usually better cared for by contralateral oblique surgery. (See section on Ptosis, complicated.)



A B

FIG 151.—The details for O'Connor's tendon transplants (The Hummelsheim operation) *A* and *B*, transplantation of slips over the superior and inferior recti. (Berens, courtesy of W. B Saunders Company.)

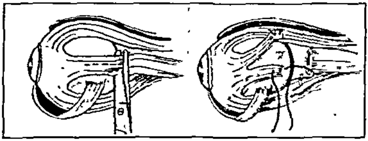


FIG 152 —Wiener's modification wherein the paralyzed external rectus is split, and these splits transferred to the intact superior and inferior recti. (Berens, courtesy of W. B. Saunders Company)

Peter's modification of O'Connor's original technique is as follows: It is best to begin with an advancement according to the Worth technique. The muscle is exposed and the sutures introduced, but not tied. A fairly good tendon stump is left for attachment of the superior and inferior tendon transplants. The conjunctival incision is now extended to the outer edges of the superior and inferior recti about 8 mm. from the limbus. The

[1] Am. Jour. Surg, Gynec. and Obst., 1935.

capsule is also incised so as to leave the sclera bare. The superior conjunctiva is held aside by a strabismus hook, while a second hook is passed under the superior rectus which is free from the capsule. The superior rectus is split by a sharp hook, in its center, and the outer half of the tendon is elevated by a small strabismus hook. A No. 1 white silk suture (waxed) double-armed is whip-stitched through the outer edge of the tendon. After the suture is introduced, the outer half, to be transplanted, is severed close to the sclera by sharp conjunctival scissors. The tendon is split for 8 mm. O'Connor recommends that a larger part of the tendon should be transplanted. In the author's experience about one-half of the tendon is adequate. The outer half of the split tendon is now attached to the upper edge of the external rectus stump. The outer half of the inferior rectus is similarly separated and is attached to the lower edge of the external rectus stump. The next step consists of a recession of the internal rectus reattaching the muscle about 5 mm. back of the stump. The recession is completed, and the conjunctiva is closed by a running suture. The advancement of the external rectus is then completed in front of the stump. Finally the conjunctival opening above and below the external rectus is closed by running sutures. The eye is closed with argyrol 25 per cent and White's ointment, 1 to 3000 bichloride petrolatum. Both eyes are closed with the usual eye pads and a gauze bandage. The eyes remain closed for three days and are redressed daily for seven days after the operation. Hot compresses for fifteen minutes are applied three times daily after the eighth day. At the end of a week, the patient is allowed to sit up. The dressing is removed at this time. Conjunctival sutures are removed on the fifth day and the Worth sutures on the tenth day. The operation probably is the most extensive of muscle operations. Reactions are marked but yield readily to hot compresses. The technique, as illustrated in Berens, appears in Figure 151.

An ocular motor paralysis from a third nerve palsy or even a complete external ophthalmoplegia can be improved decidedly by utilization of the superior oblique muscle. Jackson, in 1923, first suggested the transplantation of the tendon of the superior oblique to the insertion of the tendon of the internal rectus. Wiener, in 1928,[1] presented the first actual performance of this operation. Wiener subsequently presented a second case before the Clinical Congress of the American College of Surgeons in 1933. Peter's surgery, as he used it[2] is as follows:

A small incision was made in the upper lid over the trochlea. By blunt dissection the reflected part of the tendon was exposed and grasped by tenaculum forceps, and the tendon was severed beyond the tenaculum proximally to the globe. The trochlea was carefully exposed and opened without injury to the round tendon. A stout suture was passed through the tendon for subsequent control. A small opening was now made in the capsule of Tenon, from within out, in a suitable position over the internal rectus. Through this opening a small hemostat was passed, the suture in the tendon was grasped, and the superior oblique muscle was drawn into place and sutured to the attachment of the internal rectus tendon. The excess length of the superior oblique was cut off. The capsule and the conjunctiva were closed by interrupted silk sutures. The wound in the lid was also closed. Both eyes were bandaged, and the bandages were allowed to remain in place for five days.

[1] Arch. Ophth., vol. 57, November, 1928.
[2] Trans. Am. Ophth. Soc., vol. 31, 1933.

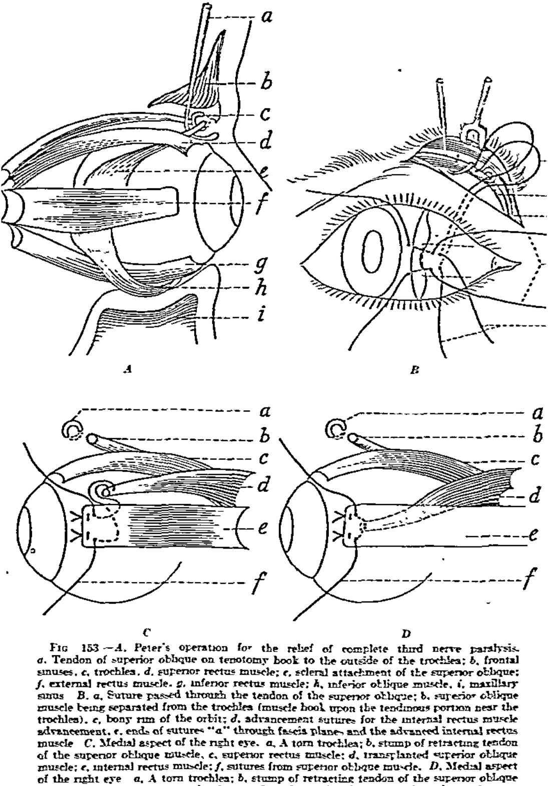


FIG 153 —*A*. Peter's operation for the relief of complete third nerve paralysis. *a*. Tendon of superior oblique on tenotomy hook to the outside of the trochlea; *b*, frontal sinuses, *c*, trochlea, *d*, superior rectus muscle; *e*, scleral attachment of the superior oblique; *f*, external rectus muscle. *g*, inferior rectus muscle; *h*, inferior oblique muscle, *i*, maxillary sinus *B*. *a*, Suture passed through the tendon of the superior oblique; b, superior oblique muscle being separated from the trochlea (muscle hook upon the tendinous portion near the trochlea). *c*, bony rim of the orbit; *d*, advancement sutures for the internal rectus muscle advancement, *e*, ends of sutures "*a*" through fascia planes and the advanced internal rectus muscle *C*. Medial aspect of the right eye. *a*, A torn trochlea; *b*, stump of retracting tendon of the superior oblique muscle, *c*, superior rectus muscle; *d*, transplanted superior oblique muscle; *e*, internal rectus muscle; *f*, sutures from superior oblique muscle. *D*. Medial aspect of the right eye *a*, A torn trochlea; *b*, stump of retracting tendon of the superior oblique muscle; *c*, superior retus muscle; *d*, transplanted superior oblique muscle; *e*, internal rectus muscle, *f*, sutures from superior oblique muscle (Peter, Extra-ocular Muscles.)

Wiener used a Weber canaliculus knife for releasing the tendon from the pulley. In both instances the ptosis was corrected at subsequent operations. Peter combined an advancement of the internal rectus with his *tendon transplant, both being done simultaneously.*

Figures 153 and 154 illustrate the surgery *of a superior oblique transplant* for a complete third nerve palsy exclusive of the lid surgery for the ptosis. Figure 154 illustrates the case of Peter's originally presented: the ocular *rotations as well as the result of the ptosis surgery* which in this instance was a Hunt-Tansley procedure.

Fig. 154.—Patient with complete third nerve palsy of the right eye. Results of the following operations: A, The conversion of the superior oblique into an internal rectus. *B, recession of the external rectus; C, Hunt-Tansley operation for ptosis.* 1, Eyes straight forward, 2, eyes to the right, 3, eyes to the left, 4, closure of the lids. (Peter, Extra-ocular Muscles.)

In discussing the correction of the paralyses of the elevators and depressors, *attention is again called to White's rules as already outlined.* It is important that one refrain from destructive surgery in these instances, as for example, double tenotomies of the two inferior obliques because of double paralysis of the two superior recti (even though the degree bilaterally may be dissimilar). In such an instance, all of the vertical elevators would be destroyed, one group by disease, the second by improper surgery utilized. The use of his (White's) diagnostic card, as illustrated in Figure 155[1] will be of great assistance in evading that serious mistake. It illustrates the degree of rotations and prism displacement present in a case of right hyperphoria following surgery *for an original* left hyperphoria wherein (from the history of the case) a tenotomy of the left inferior oblique muscle was followed by a tenotomy of the right inferior rectus muscle, the original deviation having been so marked that this was thought necessary. No further oblique surgery may be done now—for the same reasons just stated. The final result was less than one prism diopter of right hyperphoria; the left eye

[1] Personal communication.

being raised to the right hyperphoric position, saving thereby, the functions of bilateral vertical elevation by an advancement of the superior rectus muscle on the left eye, and a fairly satisfactory reattachment of the right inferior rectus muscle.

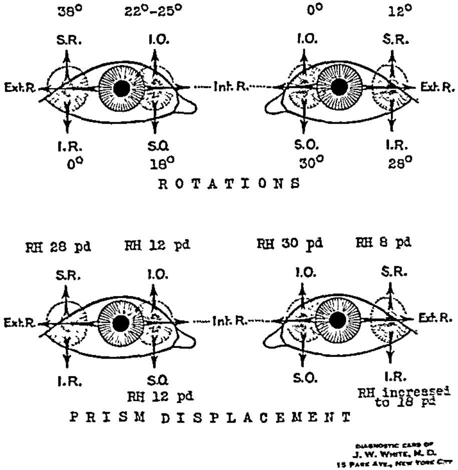


FIG 155 —White's diagnostic cards (see text).

The use of prisms for measuring not only the lateral deviations but also the *vertical deviations* (*and especially that*) has been emphasized repeatedly. The *two* underlying principles in the use of prisms for measuring the deviations are: first, the use of prisms apex in the direction of the deviation with the alternate covering of both eyes until a prism of such strength has been placed in front of the eyes to stop all movement of the eyes under cover; the second of the two is the observation of the corneal reflexes. As this is a purely objective test it is much the better of the two. Krimsky very recently stated:[1]

> Using this technique one can get an exact measurement in degree of the amount of deviation present in any one of the cardinal positions of the eye. In this manner overacting right and left hand elevators or suppressors will reveal their maximum overaction in that position. In the absence of diplopia, and even in the presence of this, the measurement of varying degrees of deviation in the varied positions of the eye is of outstanding importance.

[1] The Fixational Corneal Light Reflexes as an Aid in Binocular Investigation, reprinted from Trans Am. Acad Ophth. and Otol , 1943. (E. K. Krimsky, Major, Medical Corp. A.U.S.)

Congenital Absence of an Elevator or Depressor.—In this, one must consider also a congenital ocular palsy, not alone the anatomic absence of a muscle. This latter condition is a very rare anomaly. Congenital absence of the obliques has been reported by Harles.[1] The reports of congenital absence of the superior and inferior recti have been more common. The classical Hummelsheim procedure should *not be used in these instances.* Certainly in a case of congenital inferior oblique absence, with homolateral *hypophoria, or contralateral hyperphoria (tropia?), it is logical and permissible to tenotomize the superior rectus in the hyperphoric eye.* Residuals, if present, are then to be corrected by a resection of the inferior rectus tendon of the hyperphoric eye, rather than an advancement or recession of the superior rectus of the hypophoric eye. The reason is evident, although

FIG. 156.—Primary and secondary deviations in supposed congenital paralysis of the *left* inferior oblique muscle. (Operation revealed a congenital absence of the inferior oblique muscles.) *A*, *secondary* deviation O.D. O.S. is fixing. *B*, primary deviation, O.D. is fixing. *C*, left lateral rotations. *D*, upward rotation. *E*, right lateral rotations. Note limitation of movement in left eye in the field of the inferior oblique muscle. *F*, downward rotations.

it will stand repeating. In the presence of such an inferior oblique deficiency contralateral rotation of the two eyes results in an augmentation of the hypophoria in the palsied eye, with an even further upshooting in the opposite hyperphoric eye. The superior and inferior recti of the hyperphoric eye in this position, that is, outward rotation, are now functioning normally in maximum elevation and depression. Hence, the rationale of resection or tenotomy to the first of these, that is, the superior rectus, and recession or advancement to the second, that is, the inferior rectus. The hypophoric eye, that is, the one with the inferior oblique deficiency, now in contralateral rotation (that is, the eye is rotated toward the nose) is in a position where the *superior rectus* has lost its major elevation function.

[1] Absence of Obliques, Arch. f. Physiol., 6: 23, [illegible]

being raised to the right hyperphoric position, saving thereby, the functions of bilateral vertical elevation by an advancement of the superior rectus muscle on the left eye, and a fairly satisfactory reattachment of the right inferior rectus muscle.

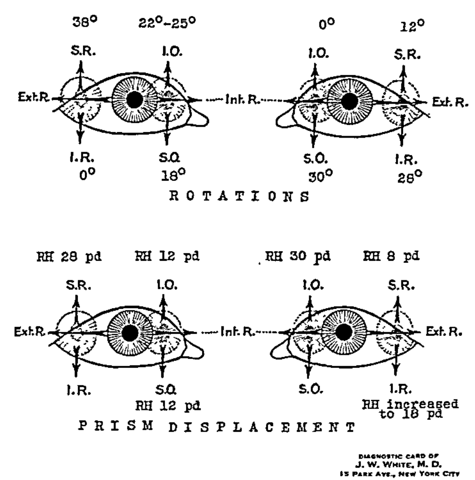


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FIG. 156.—Primary and secondary deviations in supposed congenital paralysis of the *left* inferior oblique muscle. (Operation revealed a congenital absence of the inferior oblique muscles.) *A*, secondary deviation O.D., O.S. is fixing. *B*, primary deviation O.D. is fixing. *C*, left lateral rotations. *D*, upward rotation. *E*, right lateral rotations. Note limitation of movement in left eye in the field of the inferior oblique muscle. *F*, downward rotations.

it will stand repeating. In the presence of such an inferior oblique deficiency contralateral rotation of the two eyes results in an augmentation of the hypophoria in the palsied eye, with an even further upshooting in the opposite hyperphoric eye. The superior and inferior recti of the hyperphoric eye in this position, that is, *outward rotation, are now functioning* normally in maximum elevation and depression. Hence, the rationale of resection or tenotomy to the first of these, that is, the superior rectus, and recession or advancement to the second, that is, the inferior rectus. The hypophoric eye, that is, the one with the inferior oblique deficiency, now in contralateral rotation (that is, the eye is rotated toward the nose) is in a position where the superior rectus has lost its major elevation function.

[1] Absence of Obliques, Arch. f. Physiol., 4, 23, 1880.

and has assumed instead a strong intorsion;—a tilt in the corneal meridian already exaggerated by reason of the inferior oblique insufficiency. To advance the superior rectus of the hypophoric eye, under the circumstances, means a failure in obtaining necessary elevation and the augmentation of an intorsion *defect already a disabling factor.*

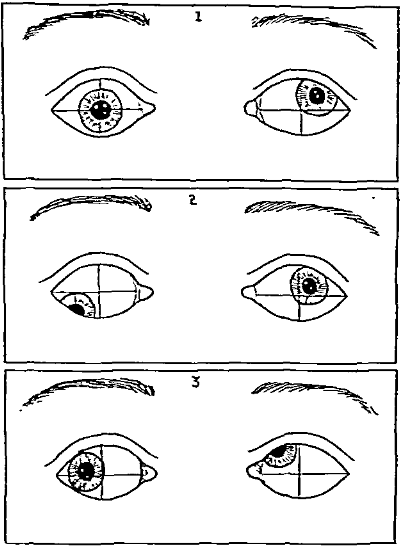


FIG 157.—*1*, Position of the eyes in repose. *2*, O.S. fixing; O.D. secondary deviation; *3*, right rotations.

Figure 156 is a case of congenital insufficiency of an inferior oblique wherein a shortening of the inferior oblique tendon is the first procedure necessary. In such a condition (subminimal involvement) the diplopia is a common complaint. Following this, surgery upon the contralateral superior and inferior recti is to follow. The simplest technique for inferior oblique tendon shortening is to uncover the tendon of this muscle, cut this, and resuture, overlapping the cut ends the desired amount, depending upon the amount of shortening necessary. Figures 157, 158, 159, and 160, are illustrations of a case of simultaneous paralyses of both the superior oblique and the inferior rectus, *i. e.*, both depressors of that eye.

Insufficiency of the superior oblique, either because of a congenital absence of the muscle or congenital or acquired palsy, must be handled similarly. In this instance, however, the paralyzed eye is in hyperphoria (tropia) and the contralateral eye is in relative hypophoria. In bilateral contralateral rotations, the hyperphoria becomes exaggerated, and the hypophoria in the opposite eye also increases simultaneously. Following similar anatomical rules, the surgery which is indicated is first, a wide recession of the inferior rectus in the hypophoric eye; secondly, or even

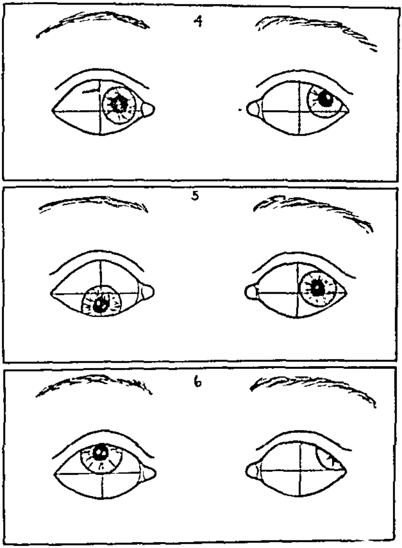


FIG. 158.—4, Left rotations. 5, maximum downward rotation. 6, upward gaze.

simultaneously, an advancement of the superior rectus in the same eye. It seems upon casual thought that such a case would be simplified decidedly by a tenotomy of the inferior oblique in the eye which has the superior oblique insufficiency. This is especially significant in view of the fact that the hyperphoria increases with contralateral rotation, that is, when the eye is in a position (rotated toward the nose), wherein maximum superior and inferior oblique elevation and depression occur. Actually, however, to

tenotomize the inferior oblique in the hyperphoric eye means that one is removing both the elevator and the depressor of the eye when rotated toward the contralateral side of the body. As stated for an insufficiency of the inferior oblique, advancement surgery of the inferior rectus in the hyperphoric eye (that is, the eye with the insufficiency of the superior oblique) is not satisfactory. Depression is not achieved under the circum-

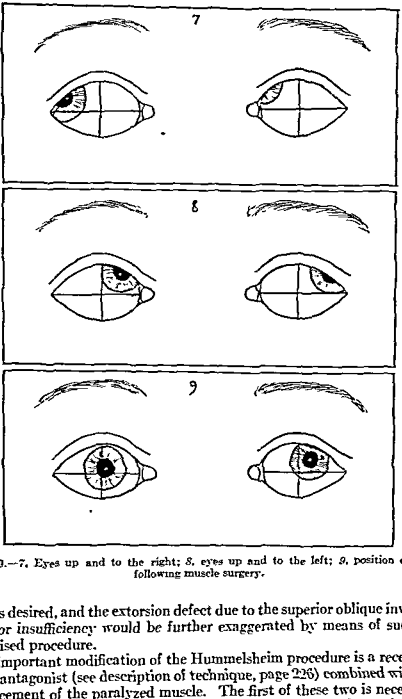


FIG 159.—7, Eyes up and to the right; 8, eyes up and to the left; 9, position of eyes following muscle surgery.

stances desired, and the extorsion defect due to the superior oblique involvement or insufficiency would be further exaggerated by means of such an ill-advised procedure.

An important modification of the Hummelsheim procedure is a recession of the antagonist (see description of technique, page 226) combined with an advancement of the paralyzed muscle. The first of these two is necessary to prevent the development of a deviation opposite to that primarily

present. This was recently outlined by Gibson,[1] in his discussion of the treatment of paralytic strabismus. Figure 161, *A*, shows the field of rotation of a congenital paralysis of the external rectus operated with a Hummelsheim technique wherein a tenotomy was done instead of a recession of the antagonist to the paralyzed muscle. As a result, the subsequent deviation was divergent with the field of rotation as illustrated in Figure 161, *B*. This latter situation, that is, the loss of convergence, is far more serious than the original situation. Further, the same technique is not indicated in an external rectus paralysis wherein the rotations are to the mid-line. It is only indicated in situations with rotation permanently limited and with the eyes converging for both near and distance.

In congenital absence of a superior or inferior rectus, the situation is just a bit different. A band of muscle, even though paretic, is wanting to hold the eye toward the corrected position. This is an important part of the operation. For instance, in utilizing the superior and inferior recti to correct the convergent strabismus of a paralyzed external rectus, one does not expect the superior and inferior recti to take on the new functions of external rotation. Tendon transplants from these two combined with the advancement of the paralyzed muscle form a broadened cicatrized aponeurosis to hold the eye at the mid-line, permitting the two obliques to function simultaneously as effective external rotators. Because of this lack of a muscle, as in a congenital absence, a transplantation of the external rectus should be utilized instead. Consider the case of a congenital absence of the inferior rectus with the eye up, slightly externally rotated, and with the corneal meridian in intorsion. In such an instance, if the external rectus is detached wholly and advanced to a point on the sclera, 4 mm from the limbus and halfway between the normal position of the inferior margin of the external rectus, and the external margin of the inferior rectus, then one should achieve depression of the eyeball and the necessary extorsion desired. Any residual exophoria should be corrected by a tuck or advancement of the internal rectus of the same eye. Similarly, in a congenital absence of the superior rectus with the eye downward, out, and the corneal meridian in extorsion, detachment of the internal rectus and its advancement and transplantation to a point on the sclera halfway between the normal superior margin of the internal rectus and the internal edge of the superior rectus, should result in an appreciable elevation and furnish the necessary intorsion needed. Any residual lateral imbalance in this instance can be simultaneously or later corrected by a recession or advancement of the external rectus. Rather recently, Caston,[2] discussed this matter of the isolated congenital absence of the inferior rectus muscle in great detail. Three of his conclusions follow here verbatim.

1. Congenital hypertropia resulting from absence of the inferior rectus muscle can be greatly improved by advancing and transplanting the external rectus muscle to a point midway between the normal position of the external and inferior rectus muscles.
2. If the hypertropia is excessive, tenotomy of the inferior oblique muscle should be combined with transplantation and advancement of the external rectus muscle.
3. The transplanted external rectus muscle then has two additional actions, extorsion and depression, both functions of the normal inferior rectus muscle.

[1] Arch. Ophth., vol. 23, No. 3, March, 1940.
[2] Arch. Ophth., vol. 24, No. 1, July, 1940.

Under ordinary circumstances, the surgery for an inferior rectus palsy or paralysis would be either a tenotomy of the superior oblique or a recession of the insertion of the superior oblique upon the sclera. These cases of congenital absence of a muscle are seldom, if ever, accompanied by the thick, fleshy hypertrophy of the antagonist, as is so commonly seen in paralysis of a muscle. For this reason, surgery upon a hypertrophied antagonist (as just mentioned) assumes a secondary importance.

Figure 162 is the primary position of a left eye up and out and with the cornea intorted in congenital absence of the inferior rectus; it illustrates a plain catgut whip-stitch prior to the tenotomy, and the advancement and transplant of the external rectus to its new position. The dotted line illustrates the normal positions of the external recti and the inferior recti. It is important to notice that the external rectus in its advancement is sutured to the sclera with its juxtalimbal position tangential to the limbus. Figure 163 illustrates, schematically, the reason for the result obtained. The position of the rectus on the schematic drawing has changed from 1 to 3; as a result the eye is elevated on the transverse axis, B-B′, and with it being tipped downward in this manner, A-A′, the vertical meridian lying intorted, is now raised to the perpendicular.

Double fourth nerve palsy is a very rare condition. The surgical treatment of one-sided trochlear palsy has been covered; that of double trochlear paralysis is rather different. The surgery outlined as emphasized by Jaensch[1] must result in an equalization of all the depressors, both right and left handed, so that the corneal meridians will not move into a paralytic cyclophoria. The diplopia from such a situation would be constantly distressing, and quite irremedial. The diagnosis depends upon the finding of a hyperphoria (tropia) bilaterally, both right and left, appearing in its greatest amount as a left hyperphoria with both eyes rotated to the right, and as a right hyperphoria, with both eyes rotated to the left. Double recessions of the inferior recti are indicated. These are to be done, however, as emphasized by Jaensch, at different times, so that it is possible to adjust the second recession to the result obtained following the first, also, to modify this second recession to the degree demanded by a dissimilar hyperphoria.

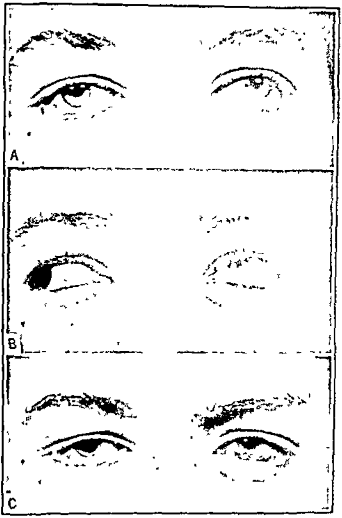
As stated before herein under the correction of paralyses of the elevators it is most important to conserve some elevation of the eyes as a bilateral function, either an inferior oblique or a superior rectus as the case may be,

[1] Klin Monatsbl f. Augenh., 102, 305-314, March, 1939.

LEGENDS FOR FIG 160A AND B.

FIG 160A — A, in repose, prior to surgery. B, right rotations C, following tenotomy of inferior oblique muscle on left, and advancement of the left inferior and internal recti.

FIG 160B — This is to be compared with A, of 160, and with Figures 157, 158, and 159. The former are of a paralysis of the two depressors of an eye, this latter is a paralysis of the two elevators of the right eye the superior rectus, the right-hand elevator, and the inferior oblique, the left-hand elevator. A of this shows the limitation of movement in the field of the right inferior oblique muscle, and B, shows the limitation of movement on right rotations (though less well) in the field of action of the right superior rectus muscle These two conditions and possibilities are to be carefully compared, one with the other, in terms of primary and secondary deviations, and over action of the synergists when the paretic eye is compelled to fix. One will simulate the other on gross examination, but to confuse the diagnoses would be serious. (See text on paralytic strabismus for the importance of surgical procedures in paralysis of the elevators)



A

B
Fig. 160

depending upon the condition under investigation, but never to destroy surgically both of these in any eye, either by tenotomy or by unusual degrees of recession. Figure 160B illustrates such a situation. In this figure, *A* is a paralysis of both depressors of the left eye, and *B* a paralysis of both elevators of the right eye.

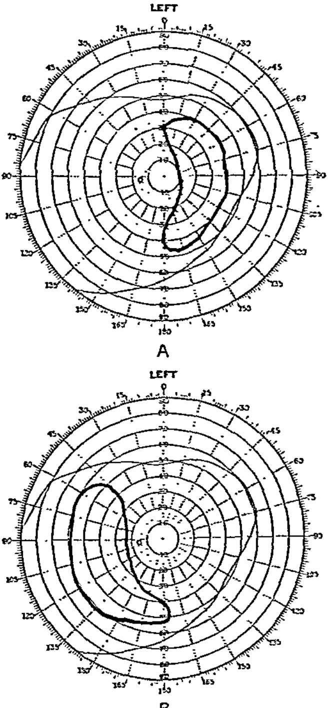


FIG. 161.—Muscle rotations before and after Hummelsheim technique wherein a [illegible] of the internal rectus was done instead of a recession [illegible] ternal

In Figure 160B in left lateral rotations the left eye shoots upward because of overaction of the left superior rectus—an overaction contingent upon a paralysis of its yoke muscle, now the right-eye left-hand elevator *i. e.*, the inferior oblique of the right eye. In right lateral rotations the

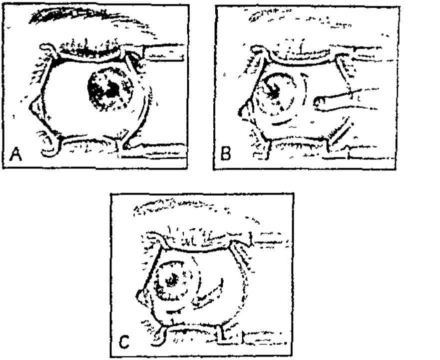


FIG. 162 — External rectus transplant

left eye again shoots upward because of overaction of the left inferior oblique muscle, an overaction *contingent upon a paralysis of its yoke* muscle, now the right-eye right-hand elevator, *i. e.*, the superior rectus

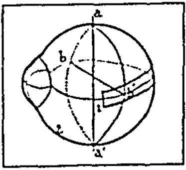


FIG. 163 — Diagrammatic sketch in perspective to illustrate schematically the reason for the tendon transplant

muscle of the right eye. Theoretically, the surgery indicated is a tenotomy of the left inferior oblique muscle to correct the hyperphoria which becomes exaggerated in right rotations, and a tenotomy (recession necessarily limited by the posterior and scleral insertion of the tendon) of the left

superior rectus to correct the left hyperphoria which becomes exaggerated with the left rotations. If this was to be done, the patient would lose all elevators bilaterally. Hence the surgery which must be carried out is that which will stay short of such a calamity.

The surgery which was actually carried out in this case, to a satisfactory result, was a tendon lengthening of the left inferior oblique muscle; second, an advancement of the tendon of the right superior rectus muscle; and last, a recession of the superior rectus tendon of the left eye combined with an advancement of the left inferior rectus tendon. This greater amount of surgery is necessary, for as was just said, to destroy all elevators will result in serious postural disturbances. Further, the younger the patient, the more important is this admonition and the more dangerous the procedure.

Convergence and Divergence Paralyses.—These conditions are disturbances in binocularity and are the result of nuclear paralyses. Their etiology is traumatic, vascular, inflammatory or neoplastic. The surgery indicated is that which will enhance the faulty function, never the reduction of the normal vergence. In convergent paralysis the surgery necessary is either a tucking or a resection of the internal recti. In divergent paralysis, contrariwise, the surgery would be a bilateral advancement of the external recti. The optimum point of correction in convergent paralysis is a fairly full correction. In divergent paralysis, however, the optimum point for correction is a rather definite undercorrection. In both instances a usable near point is the more important function. Residuals at distance can be corrected with glasses in which are incorporated the necessary prism correction for adequate use.

Occlusion Hypertropia.—This condition called by Bielschowsky "double hyperphoria," and named "occlusion hypertropia" by Verhoeff[1] is not to be confused with that just described, that is, post-traumatic double trochlear palsy. Verhoeff feels that occlusion hypertropia is the result of an overaction of the inferior obliques bilaterally, due to nuclear aplasia of the superior oblique nuclei bilaterally. The hypertropia as seen is bilateral and *alternating*, and is rather likely dissimilar in degree in each eye. Because of the overaction of the inferior obliques, Verhoeff believes that tenotomy of the inferior obliques is indicated. The condition seems to be rather *logically a case instead for recession of the inferior obliques*, when surgery seems essential. The treatment, in general, is the prism correction of the greater of the two deviations, and not a surgical problem.

Recapitulation.—A brief recapitulation of surgery of the ocular muscles is relevant here. The action of a weakened muscle is augmented by a recession, by an advancement, and by tucking. The overaction of an associated muscle in the contralateral eye, or a direct antagonist, in the same eye, is decreased by a recession and or a tenotomy. The first of these two, in decreasing the action of an associated muscle, is illustrated by the tenotomy of the inferior oblique in a case of paralysis of the contralateral superior rectus. The second of the two is illustrated by Berens'[2] recommendation for tenotomy of inferior oblique of the left eye for paralysis of the superior oblique of that same eye. The overaction of antagonist of the opposite eye may be increased by resection, advancement, and by tucking

[1] de Schweinitz Memorial Lecture, College of Physicians of Philadelphia, Nov 20, 1940.
[2] Trans Am Ophth Soc., p 253, 1934.

or by the O'Connor cinch operation. Advancement of the right external rectus for a convergent strabismus due to paralysis of the left external rectus is such an example. In general, the surgery of the phorias follows closely the surgery of the tropias; the degree of surgery necessary is perhaps the outstanding difference. The operator must differentiate a phoria, however, from a tropia, an ocular motor palsy from a non-paralytic form of phoria, and concomitant from non-concomitant squint. Paradoxical diplopia after surgery is not uncommon. As Travers states,[1] "Occasionally this diplopia has persisted for months but we have not seen a case in which it was really troublesome. Our severest case was only annoyed by it for about a week and though it persisted for several months it became gradually fainter and finally died away completely."

In general, complications of muscle surgery are fortunately not common. Corneal abrasions must be avoided during the surgery. Frequently they occur in tying the sutures, and are direct injuries to the cornea from the sutures. Hæmorrhage is oftentimes troublesome, and complete hæmostasis must be obtained before the case is completed. A suppurative tenonitis occasionally occurs though rarely. It may be due to faults in technique, and certainly some cases have occurred as the result of the use of originally contaminated catgut. In such instances the sutures must be withdrawn and the secondary results subsequently corrected. The eyeball is in jeopardy if this is not done as soon as is possible.

A postoperative dressing according to Barraquer should be used in these cases. After the bichloride ointment has been placed along the lid margin, a thin film of saline soaked cotton is placed over the closed palpebral fissure and the depressions filled in with dry, fluffed cotton. A gauze compress dressing can be placed immediately above the cotton. It is not uncommon to have a rather marked postoperative reaction. In such instances hot sterile compresses can be utilized with great benefit as early as after the first dressing.

In the final analysis the outstanding point in muscle surgery is accurate diagnosis; the constructive surgery should be based upon a plan, carefully thought out, and as carefully carried out to completion. It is far wiser to do two operations each of lesser magnitude than to do one operation of too great a magnitude, when any doubt exists with the operator as to the certain results of the latter. The anatomical and the physiological characteristics and principles connected with the extra-ocular muscles play a tremendous rôle in the attack for correcting the various possible disturbances present as well as in the end-results obtained. Disregard of these characteristics and principles will certainly result in distressing and unpardonable failures. This fact seems especially salient in this branch of ophthalmic surgery.

[1] Gifford: Edmonds Practice in Ophthalmology, 1938.

CHAPTER VII

THE ESSENTIALS OF RECONSTRUCTIVE OPHTHALMOLOGICAL PLASTIC SURGERY. FREE SKIN EPIDERMAL AND DERMAL GRAFTS. FAT, FASCIA, AND MUSCLE GRAFTS. MUCOUS MEMBRANE GRAFTS

In considering ophthalmic plastic surgery, as a specialty within a specialty (a fairly accurate statement), the author wishes to include a portion of the foreword, written by Dr. William H. Wilmer, to his earlier book.[1] It is now as apt as when written; and quite properly, for several reasons can be included herein.

The eye with its accessory structures has been consummately placed to fulfil its function as the organ of vision and as one of the chief features of expression. Nature has made an admirable attempt to protect this marvellous instrument from those outside influences that might injure its sight or destroy its charm. But even the eyelids, lashes, brow, bony walls, and cushion of fat offer but feeble defence against the violence of industrial accidents and the missiles of modern warfare.

During the Crimean War, among the combined English and French forces, eye injuries formed 1.2 per cent of all wounds. In the American Civil War, they constituted 0.5 per cent. Ocular injuries averaged 0.83 per cent among the French and German troops engaged in the War of 1870. Among the Japanese, in the war against Russia, they composed 2.22 per cent. In the American forces, during the World War, 1.85 per cent of the total number of gunshot cases involved the eye and the adnexa. During the last twelve months, there were more than 4456 eye injuries in the United States, industrial accidents forming the largest group.

From the earliest times, wounds of the orbit and adjoining parts have been the subject of the surgeon's attention. But eye injuries have become relatively more frequent in both civil and military life, and it is fortunate that the labors of Pasteur, Lister, Thiersch, Wolfe and many other patient scientific workers have already paved the way for, and made possible, the brilliant achievements of modern plastic ophthalmic surgery. Anatomy, physiology, chemistry, biology, and histology, have all contributed most generously to this humane art.

The eye possesses certain tissues that exist in other parts of the body; but it is endowed with some histological elements that are peculiar to itself, and its adjacent structures are formed most specifically for their particular functions. The restoration of these parts requires special knowledge and training, and therefore belongs logically to the domain of Ophthalmic Surgery.

No argument is required to convince the most casual that the destruction of sight is an irreparable catastrophe. But the tragedy that may lie in a distorted physiognomy is not as readily understood. Only one who realizes, "the mind's construction in the face" can appreciate the profound psychological effects upon the patient. To reconstruct such a deformity is to reconstruct the man by relieving him of the ever consciousness of, "one auspicious and one drooping eye," as Shakespeare expresses it. No rehabilitation is more important or more far reaching in its result. We owe this treatment to victims of all accidents for the sake of humanity. But those who were injured in war have a special and additional claim.

Plastic ophthalmic surgery requires the most careful and painstaking study of each individual case before undertaking the actual operative procedure. Even the period of time that should lie between the injury and the operation, is a necessary consideration. The surgeon must possess to the fullest sense the conception of "*suaviter in modo, fortiter in re*." He must possess great boldness in making the size of his flaps large, and the removal of all scar tissue thorough, yet at the same time he must practice the most rigid economy in sacrificing muscle tissue or normal skin.

[1] Newer Methods of Ophthalmic Plastic Surgery, P. Blakiston's Son & Co., Philadelphia, 1925.

against graft infection in plastic surgery; "by applying, for a week before the grafting, gauze soaked in the discharge from the granulating wound on the surface of the flap to be transplanted."

Elschnig reports a successful take with an isograft from a sister, in the plastic treatment of ichthyosis congenita with ectropion.

OLLIER-THIERSCH GRAFT

In the use of an Ollier-Thiersch graft, Gillies and Esser, separately, have explained a method which can be most highly recommended for the correction of the smaller defects from scar tissue contraction deformities with a loss of considerable soft tissue. The terms epithelial inlay and outlay are applied to this method. All scar tissue is first resected, and then, by deep wound margin undermining, the skin about the injured area is allowed to move to its proper normal position.

In this dissection, care must be taken that muscle and nerve tissues are not disturbed. This is especially important in a case of the repair of the upper lid because of a scar tissue contraction ectropion with or without extensive loss of epidermis. The satisfactory movement obtained by the operation will be most gratifying if this point is remembered. Dental modeling compound is first softened and then molded into the area formed by the dissection. All bleeding and oozing must first be stopped. (This compound can be sterilized in bulk in lysol.) The stent is softened in hot saline and then molded to the desired shape by moderate pressure. By means of an alcohol lamp flame and of cold saline, used first to soften the exterior and then to harden it, the surface of the mold can be made perfectly smooth and of the correct shape. Esser attempts to make the mold an accurate impression of the normal surface. When this mold is in position, it should be just possible to approximate the skin edges without undue tension. The mold should be of a size sufficient to fill the defect completely, after the sutures have been placed. At this time, after the sutures are placed, the original defect is uncomfortably exaggerated. This should cause no concern; the ultimate result is obtained upon the removal of this mold. A thin graft is then cut from the upper outer aspect of the arm, or from the inner middle aspect of the thigh. The graft must be cut in one piece and without holes. Boards or sterile tongue blades are to be used to hold the skin taut. When cutting a graft the razor should no more than scrape the layer of the true skin. Tiny pin-point areas of hæmorrhage at the site of the graft, and appearing a few seconds after the razor has lifted the graft, are the only bleeding allowable. The graft is then placed in warm physiological salt solution, 100° F., for a time until a sterile petrolatum gauze dressing can be placed upon the arm or the thigh from which the graft has been cut.

The mold which has been previously prepared is wrapped with this graft, the epithelial surface innermost. All portions of the mold must be covered, but any redundant edges of the skin may be removed with sharp scissors. The graft, which must not be pinched or touched with the fingers, can be lifted from the salt solution and placed over the mold by using two straight forceps. The mold should lie upon a dampened piece of gauze. The graft can be stroked over the mold until it adheres smoothly to all surfaces and facets of the mold. From this time on the mold with the adherent graft is to be handled with fixation forceps. The mold is then placed into the defect

into the site of the skin defect, covering as in some cases, the lower lid, the closed palpebral fissure, and the upper lid, and well down below the level of the bony orbit. It is held in place for a few moments so that it takes accurately the reverse shape of the underlying tissues and the bony configuration of the face. The mold must extend over onto contiguous normal

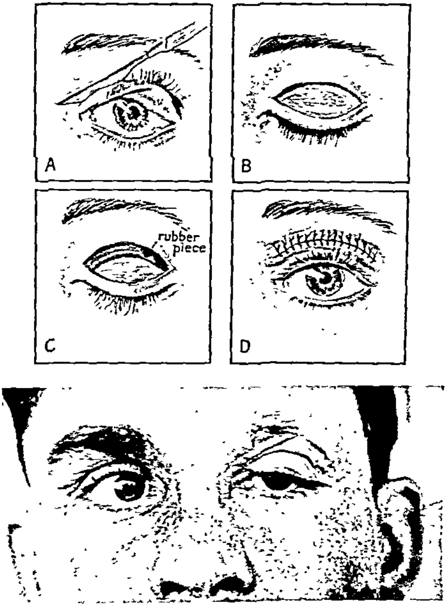


FIG. 164.—Esser's inlay for ectropion. Large photograph shows the graft shortly after the first dressing.

skin surfaces. The gauze fluff is then lifted with the molded shell of dental compound adherent. It is plunged immediately into cold water to harden. The gauze fluff can then be readily separated from the shell. Without the assistance of this gauze fluff it would be impossible to pick up the semi-solid stent, molded thus, without consequent deformity. As soon as it is solidi-

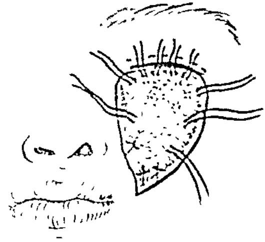


Fig. 165.—Sketch to show sutures. (See Figure 166.)

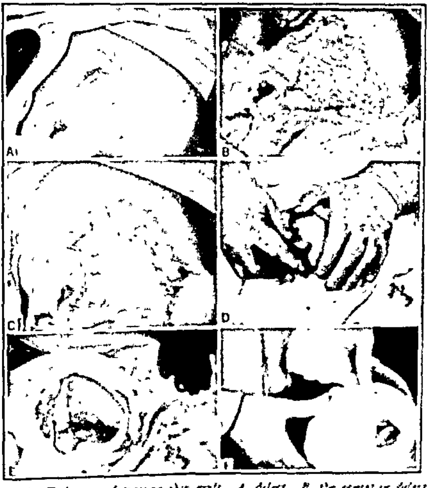


Fig. 166. Technique of massive skin graft. *A*, defect. *B*, the cosmetic defect for correction. C, formation of mold. *D*, graft placed with sutures. *E*, fitting of mold. *F*, dressing.

fied, it is perhaps wise to refit it once more to be certain of its proper shape. It may then be laid aside. The graft is now carefully fitted into position, as no sutures are used unless the graft is large. If so, sutures are to outline the graft, inserted not at the edges of the graft, but within the edge, and lightly tied. Figure 165 illustrates this.

Figure 166 is a massive defect corrected with a free graft, sutured into place, and held for recovery with a mold for a pressure dressing.

An early or immediate contraction will occur in the graft and is in these instances especially noticeable, being as high as 20 to 30 per cent of the total surface of the graft with some individuals. The graft can be smoothed out carefully with a cotton applicator soaked in sterile liquid petrolatum. If it is being placed upon one of the lids over a socket which has no eyeball, a mold must be placed into the socket for proper support and counterpressure. The underlying surface of the shell is then also covered with sterile petrolatum and placed directly upon the graft, carefully in its proper position. A pressure bandage which incorporates a portion of a dry elastic sea sponge and which will not creep is then placed over the graft and is not disturbed for ten days. The opposite eye should be kept bandaged for three days. The initial dressing, ten days after the operation, should be done very carefully. As the bandage and the gauze are removed each individual layer must be lifted carefully and separately. When the shell is reached, the edge of it should be first lifted with a blunt instrument. Then by careful stroking between the surfaces the shell can be raised without damage to the graft. This should be covered with rubber tissue or an oiled silk and gauze dressing, exerting a slight amount of pressure for two more days. The graft can then be cleansed with boric acid solution and redressed every other day for a period of two more weeks. At this time massage should be started as previously mentioned. The marginal adhesions of the lids, if these are used, may be severed at any time after all contraction has ceased, one to three months after the operation. Some experimental work is now being done to obtain a glue of human leucocytic tissues which will form firm cohesion of a graft to a dissection site without the necessity for pressure dressings.

DERMO-EPIDERMIC GRAFTS

The method just described is especially applicable to those lid deformities wherein the lid margin is irregular or wherein there is a loss of hair line, due either to trauma, to disease, or following previous plastic reconstruction of the lids; for these, instead of a razor-cut graft, a full thickness graft from the normal opposite lid is used. The lid margin edge is incised with an angular keratome. This incision is widened with scissors and forceps until the lid margin can be placed at its proper level, or until there is a spindle-shaped area formed, at times ½ to 1 inch in width at its widest portion. Black silk double-armed sutures should then be passed through the shelf of the lid margin remaining, mattressing them through this margin into the tissues immediately opposite their exit in the tissues of the other lid and there tied over small rolls of gauze or through perforated rubber plates. The margins of the lids may first be freshened to secure adhesions. In this way the area of the dissection is held open, and at the same time a considerable amount of lid fixation is obtained.

A small free graft is then cut from the tissues immediately above or

below the eyebrow to fit the area formed by the corrective dissection. If the graft is to be taken from below the eyebrow, the opposite upper lid must be used. Tissue from this region contracts but little and no allowance for this is necessary. If it is taken supra-orbitally, the lower edge of the graft should include a line of hairs from the brow throughout its entire length. If the graft is taken from the upper lid its upper edge should include these hair follicles. In this case allowance must be made in the shape of the graft being cut, because it will be inverted to bring the hair line into position. The graft is now carefully sutured in the dissection defect and dressed with a paraffin or stent shell as in the type of cases just discussed (Fig. 167).

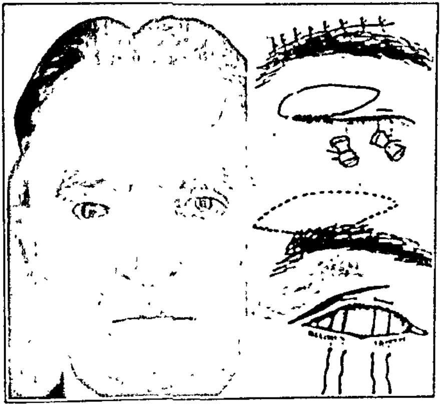


Fig. 167. Hair bearing full thickness graft.

This second type of free skin graft is a true skin graft. When grafts are lifted with a razor the true skin is usually untouched. Under certain conditions, however, the entire thickness of the skin is required. The graft is outlined with a sharp scalpel at the site selected, and then lifted from its position with one of a number of instruments. A von Graefe knife can be used, an ordinary scalpel, or sharp straight iris scissors. The graft should be held at its extreme edge with iris forceps or sharp hook, or with a suture and raised slowly. The hæmorrhage is to be controlled with dampened gauze sponges. As soon as the graft is free, it should be placed upon a moistened piece of gauze and the subcutaneous tissue and fat snipped off with sharp, curved iris scissors. The best area for resecting this type of graft is from the upper superior portion of the upper arm with the hand held in supination. After the graft is removed and trimmed, it should be

placed in a basin of warm physiological saline solution while the defect on the arm is being closed with an intradermic suture. If the graft removed is of any extent, the edges of the defect are undermined for 1 or 2 inches before the suture is placed. The closure of the defect will thus be facilitated, and at the same time it will be more comfortable for the patient. The graft is then placed in the site prepared for it by the previous dissection and held there with as many sutures as are necessary, depending upon the size of the graft and the correction desired. Reliance is placed largely upon pressure to hold the graft in place. In this type of graft, excepting those cut from the upper lid, there is more initial contraction than in the razor cut Ollier-Thiersch graft. Immediately after its removal it will shrink 30 to 40 per cent of its original size. Later contraction, however, is negligible, unless necrosis of some portion of the graft should develop. There are two definite limitations to this type of graft: one as to the size which can be used; the other as to the thickness of the graft. It is therefore not practicable for all lid repairs. It can be used, however, with considerable success for the repair of scar tissue contraction ectropion of either lid due to the loss of tissues immediately below or above the lid margin. The margin, however, *must be intact. Such defects are usually from injury or from neoplasm* resections of the skin of the cheek.

A B

Fig 168.—A, ectropion, upper lid, OD, corrected with full thickness graft from opposite lid. B, shows extent of closure of all lids.

The patient shown in Figure 168 had a cicatricial ectropion of the upper lid on the right. A free skin graft was resected from the upper lid on the left (rather than from any other site in this instance), placed into position, and then covered with a conforming shell of dental stent. The illustration on the right of the two shows the satisfactory degree of closure possible and at the same time illustrates that a graft, even as large as this was, can be taken from the upper lid upon the opposite side without any resulting ectropion there.

Adherent scars over the malar bone with resulting ectropion are correctable with this variety of graft. The important factor in the preparation *of the bed for this graft is the wide and careful resection of all adherent*

eyebrow graft should be inclined towards each other so that a cross-section of the graft would show it to be wedged-shaped with the skin surface forming the base. The graft should then be placed into warm normal saline solution while the scalp defect is being closed with black silk. The graft can be trimmed to proper size without maltreatment. The subdermal fat

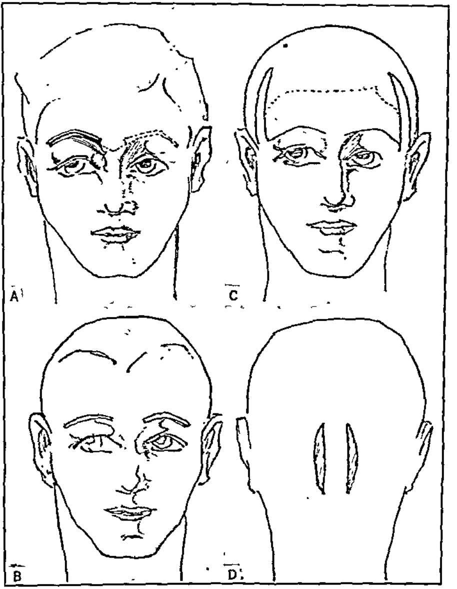


FIG 169 —A, pedicle flap for one eyebrow to the other; B, full thickness graft from one eyebrow to the other, C, pedicle flap from the scalp, D, free skin graft from occipital scalp. (Courtesy of P Blakiston's Son & Co)

may be removed with sharp scissors until the black dots of the hair follicles are just visible. These should not be injured. In the case of the lid margin, the graft used should be from beneath the eyebrow, utilizing the skin of the upper lid. The lid margin is split with a keratome and a graft 3 mm. wide is placed into this incision and held there by pressure and with a

are all free skin grafts. Immediately after the operation, many of the hairs in the graft will fall out. At the end of two weeks they begin to return. At first the hairs are rather scraggly and irregular but later, they become quite luxurious in their growth.

The second method is one suggested by Morax (Fig. 169, *B*). It can be done as was originally recommended for a pedicle flap. The opposite eyebrow is simply split and the upper crescentic portion transferred to the opposite side. Several sutures will be necessary to hold this graft in place. Its later treatment is no different from that just mentioned.

FIG 171 —*A*, cicatricial ectropion with the loss of the eyebrow, *B*, before epicanthus operation and after graft into lid, *C*, completed with occipital scalp graft for the eyebrow.

The third method differs from the first in the manner of placing the graft. Instead of one graft of the desired width, two or three of a very narrow width are placed into parallel incisions in the desired position for the eyebrow. The incisions are made 1 to 2 mm. apart and are carried down to the periosteum. The grafts are cut 2 mm. in thickness and are placed, after trimming, in these parallel incisions. Three such grafts are usually sufficient. No sutures are used and the grafts are then treated in their postoperative care exactly the same as has been explained above.

FAT, FASCIA AND MUSCLE GRAFTS

Fat grafts are seldom entirely successful. Shortly after implantation the fat may undergo rapid atrophy, and often nothing remains of it but resultant scar tissue. It undergoes the same course as does fat on any other

The technique for the use of fascia and muscle is not different. The fascia, if used alone, can be removed from the same area as for the fat. If muscle tissue is to be used as well, it will be necessary to make the skin incision nearer to the anterior-superior spine to get into the region of the muscle fibers of the tensor fascia lata. The method of anesthetizing this site has been discussed. Through a lone incision made in the outer aspect of the thigh exposing the heavy fascia one may readily remove a long, wide piece. If a Fuld separator and Grace stripper are used, these grafts may be obtained through a relatively small incision. When the grafts have been removed, the size of them depending upon the correction planned, they are to be placed into warm physiological saline until the area from which they have been cut is closed. The incision for filling out a thinned atrophic upper lid should lie in the upper outer angle of the lid following the normal curve of the bony orbit. In position, it is to be just external to the line of the external canthus passing across this line at an angle of 30 degrees with its lower extremity inclined away from the canthus. This incision needs to be only 2 cm. in maximum length for the introduction of the graft,

FIG 173.—Removal of fascia graft from the thigh. Graft in operator's hand.

otherwise the graft will tend to protrude and to be caught in the suture line while the incision is being closed. Dissection is carried backward into the depth of the orbit and along the entire line of the upper lid toward the nose. It is best done with blunt-pointed scissors. The care with which this dissection is done makes the small incision possible. After the skin has been lifted, the muscle and fascia, with the fascia uppermost, can be introduced into this slit-like opening and smoothed out with the side of a pair of forceps. All hæmorrhage must have stopped before the graft is placed. If the globe of the eye has been lost, it will be necessary to place a mold of gutta percha or dental compound inside the socket to obtain a support for the moderate pressure desired. Figure 173 shows the removal of a fascia graft from the thigh and the graft after removal lying upon the operator's hand. Figure 174 is a case of high degree atrophy of the retrotarsal tissues of the upper lid following an old enucleation, a rather conspicuous defect which has been corrected by such a graft. This type of defect, if extensive, had better be corrected with scales of cartilage instead of fat and fascia. Figure 175 shows a scar resection and sliding pedicle flap correction of a misplaced eyebrow. The immediate healing is illus-

trated in *B*, the correction of the retrotarsal atrophy in *C*, and the end-result in *D*. Figure 176 shows the details necessary for this surgery correction. Figure 177, *A* and *B*, illustrates the fascia correction of a bony depression above the eyebrow resulting from an earlier radical frontal sinus

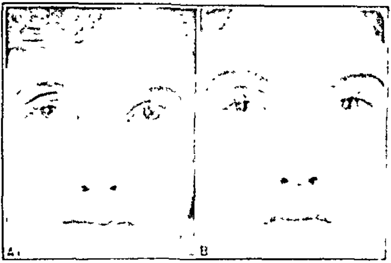
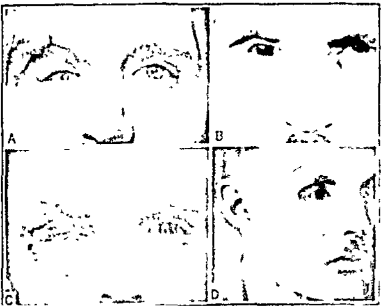


FIG. 174. Retrotarsal atrophy of upper lid before and after a fascia graft.



graft difficult to hold and even more difficult to embed properly. Fascia lata as a graft can be utilized much more extensively than it is. Sunken and atrophic lids following an old enucleation, depressed outer canthal angle deformities, depressions following osteomyelitis and sinus surgery, and large atrophic orbita, especially those seen after traumatic enucleations, are some of the indications. As Wheeler[1] said, "There is just one important requirement. That requirement is complete covering so that the implanted fascia will not be exposed to the air. The surgeon should provide security of skin covering by 'halving' the skin union over the graft and by making accurate apposition of the skin margins."

Strips of fascia lata are also of great value for suspending a ptosed eye as does the normal suspensory ligament of Lockwood, in those instances wherein other necessary plastic procedures have resulted in the removal of floor and even part of the lateral wall of the orbit. McKenzie[2] has reported such instances following surgery for neoplasm of the maxillary antrum.

MUCOUS MEMBRANE GRAFTS

Mucous membrane grafts, and we are indebted to Van Milligan for first advocating them, when used should be taken from inside of the mouth on the buccal surface. They are never of any great size, and after being lifted, they must be cleaned of all adherent submucous tissue with sharp scissors. There is only one defect for which these grafts are to be used, and that is for the correction of conjunctival defects with an intact eyeball. A posterior symblepharon of any extensive degree is quite readily corrected with this type of graft. Recently, a case in which a pterygium had been operated upon three times, by two McReynolds' transplants and an initial resection, was readily corrected with a mucous membrane graft. Due to the loss of the conjunctival tissues the eyeball was for all purposes fixed in a state of symblepharon. Diplopia was almost constant, because of the fixation of the eyeball to the palpebral conjunctiva.

The lower palpebral conjunctiva may be replaced at times with skin, but never the orbital conjunctiva. Popular opinion to the contrary, skin always remains skin, and if grafted upon the globe of the eye it still behaves physiologically the same as the skin in any other part of the body. The superficial layers are lifted by the growth of the underlying structures and are not removed by friction from clothes, and by bathing. As a result they pile up upon the surface of a graft on the globe and cause a most uncomfortable conjunctivitis, unless they are frequently removed with the friction of a small, damp, cotton wound applicator. The closure of the lids over the globe of the eye does not furnish friction sufficient to remove these normal desquamations. In utilizing a mucous membrane graft this complication is apparently not present.

The conjunctiva is first released and undermined so that it will move into a position without tension and without limiting the normal movements of the eyeball. The defect which remains is then accurately gauged by a pattern cut from oil silk and carefully fitted. One needs to allow but little, if any, for shrinkage with a mucous membrane graft. The pattern

[1] Collected Papers of John M. Wheeler, p. 428.
[2] Am. Jour Ophth., Series 3, vol 25, No. 8, August, 1942

FIG. 176. Details of the surgery of case in Figure 175. A, skin incision. B, formation of pockets for implant of fascia. C, introducing the fascia. D, sutures. E, completed result.

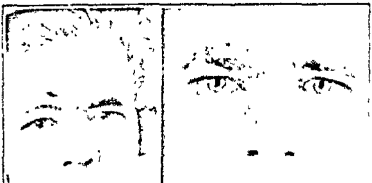


FIG. 177. Case: correction of bone depression [illegible]

is then placed upon the mucous membrane on the inside of the cheek and a graft cut from the mucous membrane there, matching this pattern accurately in size and shape. The duct to the parotid gland should not be damaged. At the time of its removal the graft should be kept as thin as is convenient, but this is of no great concern because it will need to be subsequently trimmed. As soon as it is removed, hæmostasis is completed in the mouth wound, and the incision line carefully closed with fine dermol or silk sutures. The mucous membrane graft is then placed upon a moistened towel, the epithelial surface in contact with the towel, and the posterior surface carefully trimmed with sharp-curved scissors until all tissue has been removed except the thin rather slimy mucous membrane layer. It can be pegged out, with common pins, upon a tongue blade, the epithelial surface lowermost, and readily trimmed in this manner. When it is in this condition one is agreeably pleased with the ease with which it can be worked. The graft should not be buttonholed during this trimming.

Clay and Baird[1] report cases of orbital repair with the modified mucous membrane-epithelium from the prepuce and labia minora. They state it to be ideal for all conjunctival grafts and that an adequate amount is available for almost any reconstructive work.

Fig 178.—Symblepharon from alkali burn. Case before correction showing extent of symblepharon and of corneal involvement. (Courtesy of the Am Jour. Ophth., vol 20, No 9, September, 1937.)

From now on the graft is utilized under varying procedures depending upon the correction necessary. These different methods will be detailed later. One is included herewith to illustrate this point. It is a satisfactory correction for a completely lost inferior cul-de-sac. Figure 178 was the case before the correction; and Figure 179, *A* and *B*, after the correction, with the patient looking up to show the very satisfactory graft obtained; with the patient looking to the side to show the absence of limited ocular motility (this to be compared with the very evident cicatricial fixation of the eyeball seen) and with the patient looking straight to the front. Figure 180, *A* and *B*, shows the incision of the symblepharon and inferior cul-de-sac; *C*, the fitting of a glass conformer into the dissected cul-de-sac; *D*, the mucous membrane graft lying upon a towel, its posterior surface being trimmed; *E*, the mucous membrane graft has been placed over the palpebral fissure, epithelial surface outermost, in a smooth, even manner so that when the

[1] Jour Am Med Assn, 107, 1122, October, 1936.

palpebral fissure beneath it is opened the mucous membrane graft can be moved by the glass or metal conformer into the dissected cul-de-sac prepared for it; and *E*, shows the edges of the graft being smoothed out evenly

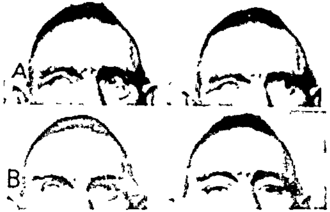


Fig. 179. *A* and *B* after the correction showing extent of ocular movement. (Courtesy of the Am. Jour. Ophth., vol. 20, No. 9, September 1937.)

Fig. 180. Surgery of a mucous membrane graft into the cul-de-sac; see text. (Courtesy of the Am. Jour. Ophth., vol. 20, No. 9, September 1937.)

on the lid margin prior to closure of the lids. The application of a pressure dressing or bandage is necessary, both eyes being kept closed with the dressing. The immediate 5 to 10 per cent contraction of the mucous mem-

brane graft is all that will or should occur if infection does not develop. If any sutures are used they must be of the finest silk. The healing is very prompt. The intermarginal sutures may be removed at the end of four days; at the time of this first dressing the cul-de-sac should be carefully cleansed, the cornea inspected for any damage to the epithelium (because of the conformer), and the lids kept closed after that for four additional days, with a slight pressure dressing. After the removal of the tarsorrhaphy sutures, careful irrigation with warm boric acid solution will cleanse the cul-de-sac of all accumulated secretions. The conformer may be removed permanently after the seventh day. This same irrigation should be continued for a week to ten days, at which time the case may be discharged.

Excess mucous membrane, as that adherent to denuded cornea, is to be subsequently removed, and the denuded cornea tatooed with gold chloride solution.

the fixed wound defect incline away from the perpendicular. He devised a "slant-cutting" scalpel for this purpose. In cutting pedicle flaps, the edges are always to be inclined away from the epidermal surface toward the deeper tissues; that is, the skin surface has a larger area than the under side. This same author has emphasized the various lines of tension, "Langer's Tension Lines," relative to the amount of scarring. These lines circle the eyes in the direction of the orbicularis fibers and from there radiate up toward the scalp in the center of the forehead, out toward the temple, and down around the alæ of the nose toward the cheek. As Hunt states, "Incisions which cross these lines will of certainty be followed by wider scars

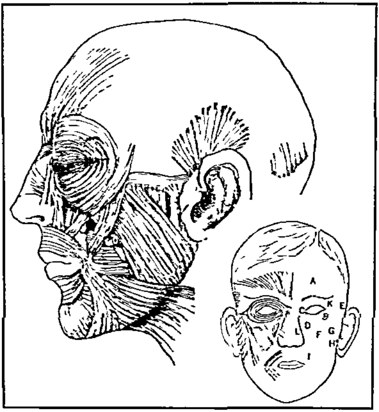


Fig. 181.—The muscles of the face and the lids, and the skin tension lines which correspond. *A*, occipito-frontalis, *B*, orbicularis oculi, *C*, canthal angle ligament; *D*, fibers of the quadratus labii superioris; *E*, anterior auricular; *F*, caninus, *G*, zygomaticus; *H*, masseter; *I*, orbicularis oris and buccinator, *K*, temporal fascia; *L*, compressor alaeque nasi.

than if care were taken to incise in the direction of the tension." Figure 181 illustrates the muscles about the face and the tension lines which correspond to the action of these muscles as they modify the line for pedicle flaps.

The simplest of all flaps are those planned for the replacement of tissue lost from the lids. This is illustrated in Figure 182, *A*, *B*, *C*, *D*, and *E*. In the first, there was a loss of most of the upper lid. In cases like this, the incision and the dissection should be continued until the lid margin can be

sutures are then gathered upon hæmostatic forceps and lifted away from the flap. After that the flap can be dissected from its position and moved. As the sutures are already placed, it is only necessary to tie them, and the flap lies firmly in its correcting position without any delay to endanger the vitality of the flap and without that difficulty in introducing the sutures which is so common with flap operations because of the mobility and flaccidity of its correcting head. Pinching the flap while introducing sutures is always to be avoided. After the skin incision, above the brow, is closed, the entire area is covered with paraffinized gauze, a bandage is applied, and both eyes covered. The pressure dressing should exert pressure upon the correcting head, but must be arranged with gauze fluffs to spare

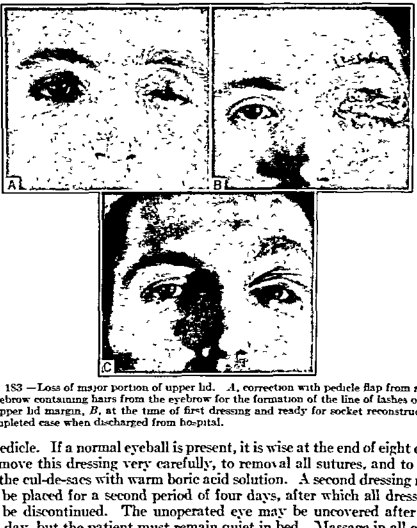


FIG. 183 —Loss of major portion of upper lid. *A*, correction with pedicle flap from above the eyebrow containing hairs from the eyebrow for the formation of the line of lashes on the new upper lid margin, *B*, at the time of first dressing and ready for socket reconstruction; *C*, completed case when discharged from hospital.

the pedicle. If a normal eyeball is present, it is wise at the end of eight days to remove this dressing very carefully, to removal all sutures, and to irrigate the cul-de-sacs with warm boric acid solution. A second dressing may then be placed for a second period of four days, after which all dressings may be discontinued. The unoperated eye may be uncovered after the third day, but the patient must remain quiet in bed. Massage in all cases of pedunculated flap operations should be started as soon as the dressings have been removed.

Figure 183 is the completion of such a case wherein a large pedicle flap was moved from the forehead to the very much deformed and defective upper lid. It can be seen that the entire upper lid is replaced by the pedicle flap.

Richet modified it even further by using two parallel flaps cut in a Z-shape. The proximal and distal flaps are then changed in their position and sutured as seen in Figures 187 and 188. Blaskovics modified this somewhat for the correction of lower lid outer canthus defects. Imre's procedure, however, is even more satisfactory. The Burow's triangles and the original Burow's plasty are well illustrated in Figures 189, 190 and 191. In Figures 189 and 190, major triangles are utilized, and in Figure 191, minor triangles are cut

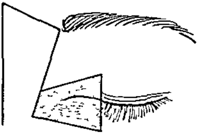


Fig. 187.—Blaskovics' plasty. First step.

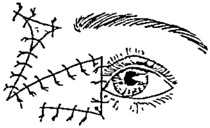


Fig. 188.—Blaskovics' plasty Result.

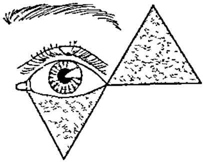


Fig 189 —Burow's plasty. First step.

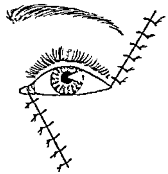


Fig 190 —Burow's plasty. Result.

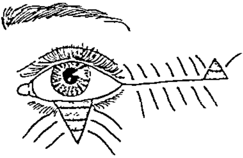


Fig 191 —Burow's blepharoplasty (modified).

for the mobilization of skin. The major Burow plasty is most wasteful, however, and there are other means at our command for the correction of as gross a defect as this illustrates. Rollet also used Z flaps very satisfactorily for a major defect in the upper lid as seen in Figure 192, while Lagleyze utilized rather similar ones for the lower lid. In his technique, it was not aimed so much at the correction of a deficiency in tissue as applicable to senile ectropion.

flaps supplied by vessels from the deeper layers. Their superiority is especially apparent when used for the replacement of mucous membrane, particularly in the cheek, mouth, nose, and the orbit. One should always be able to close the secondary defect without producing noticeable traction on the lower lid or on the mouth. This technique will have an ophthalmological possibility, at times.

In Monk's modification of Esser's arterial flap as shown in Figure 193, the dotted line illustrates the position of the angular artery. A pedicle, which encloses the angular artery, must be carefully dissected out. The angular artery with its vein lies on the same level with the external canthal angle passing beneath the circular fibers of the orbicularis at the temporal margin of the muscle. Monk advised, in the use of these arterial flaps, that

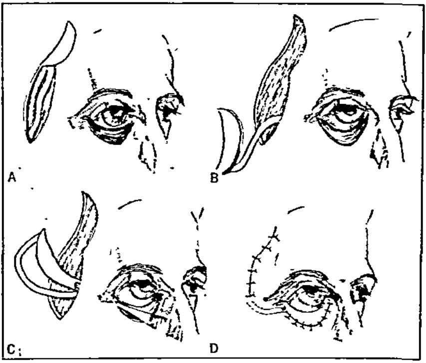


FIG 193.—The technique of Monk's for an arterial flap. (Courtesy of P. Blakiston's Son & Co.)

the pedicle which consists of an anterior branch of the temporal artery and vein with the surrounding subcutaneous tissue be utilized for lower lid defects only after the correcting graft has been first pregrafted before transplantation. By this he means that the skin be first outlined and partly lifted, then sutured, without transplantation, and kept in its original place for about ten days. In this way the arterial supply to the graft has been appreciably and physiologically augmented. When the graft is finally lifted out for transplantation the vascular pedicle is more readily dissected out and carries a far richer blood supply.

Esser frequently employs flaps pediculated below and containing up to their ends the angular artery with the veins. He also shows that it is possible to employ flaps nourished by a reverse circulation. The angular

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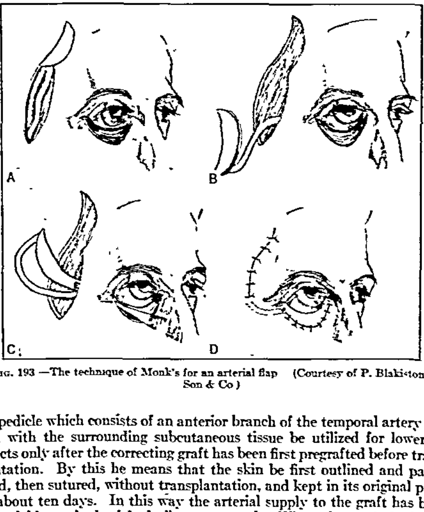

FIG. 193 —The technique of Monk's for an arterial flap (Courtesy of P. Blakiston's Son & Co)

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the chest or neck to replace an extensive loss of soft tissues due to injury or following the operative measures for the removal of malignant growths about the face. The author has assisted at the transplantation of flaps from these areas for the correction of gross defects when the flap transplanted was at the point of suture more than 16 square inches in area. While this usually is not in the field of the ophthalmic surgeon, it can be mentioned here as relevant. In rhinoplastic work large flaps are often used in this same manner from the forehead, neck, and anterior surface of the forearm. In this latter method a suitable plaster cast is necessary to hold the arm in position while the transplanted flap is growing, a method spoken of as the Italian method.

In extensive burns about the face and the eyelids, Gillies describes a method in which a double tubed pedicle delayed flap is used. The correcting portion of the flap is outlined upon the chest and the two lateral cervical pedicles to it lifted and tubed ten to twelve days later. The wide head between the two pedicles is then moved upward into its correcting position, as in a case, for example, where it is necessary to replace both lids of the two eyes, the skin over the bridge of the nose and perhaps some

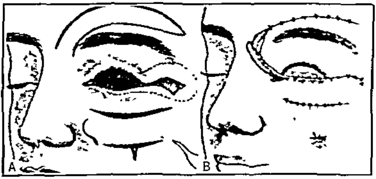

FIG. 194.—Tubed pedicle flap combined with a sliding flap from below for the reconstruction of the lower lid and the inferior cul-de-sac.

infra-orbital tissue as well. After this head has grown into place, the pedicles are reopened and returned to their original position. Subsequent minor plastic work such as the correction of a remaining ectropion, and the formation of lashes and eyebrows, can be completed at any time after the return of these pedicles.

Snydacker suggested the use of large pedicle flaps lifted from the skin of the neck. The defects for which this method is applicable will be considered under Lid Repairs. The pedicle of this flap, when in position, from the eyelids across the skin of the face to the region from which it has been raised, is protected from damage and contact to its under surface from the skin of the cheek, by gutta percha or oiled silk strips placed under and above the pedicle. These strips at the same time hold the flap smooth to prevent it from curling upon itself. This long pedicle is returned, if so desired, to the original site from which it came, after a sufficient period is allowed to elapse for healing to take place in the corrective apex of the flap. Snydacker[1] recognizes an objection which might be made against using

[1] Arch. Ophth., No. 1, 1906.

discarding it, he carried out further necessary plastic restoration. Delmano of Madrid and Fulchen of Germany also used the operation with this modification. The results from this operation are very successful especially when one is unwilling to use the less sure and less easy Italian method (Fig. 196) of correcting deformities. The technical difficulties of this "methode l'italienne" are hardly worth while, considering some of the mediocre results obtained through its usage, when one has so valuable a procedure as this advanced by Snydacker.

Fig 196 —The Italian method for using a pedicle flap

The Snydacker technique demands a flap from the angle of the jaw, following the line of the sterno-cleido-mastoid muscle downward for a distance of 25 cm. Considering the 30 to 40 per cent contraction which takes place in the flap, the head of the graft will then come into proper approximation to the defect for correction without tension on the graft.

In cutting the flap one must carefully measure the loss of substance for correction, and plan for a shrinkage of 30 to 40 per cent, and if in cutting, one follows obliquely the sterno-cleido-mastoid, there is little chance of having the flap strangle *itself*. There is no reason why a flap of 25 cm. will not live as well as one of 5 cm.

Figure 197 is the utilization of Snydacker's technique. *A* shows the original defect. The case was one of a gunshot wound wherein a cartilage graft was first necessary to rebuild the floor of the orbit, in that the fundus of the orbit and the maxillary antrum were one. This had already been done before *A* was photographed. *B* is the elevation of the cervical pedicle as it has been tubed; *C*, and *D* show the elevation of the pedicle and its correcting head; in *C* it has grown into position and the patient is now wearing an ocular prosthesis; and *E* shows the resection of the pedicle and the suturing of its end to complete the correction desired. In this instance the pedicle was discarded though it could have been reopened and returned to the skin of the neck if it had been necessary.

Blair in 1921, and Pickerill, and White in 1922, claimed increased viability for these flaps so that they may be grafted into septic cavities without damage by sloughing. The method should be applicable to the repair of orbital sockets.

In extensive deformities of both lids as well as of the socket, the correction often can be accomplished with a two- or three-tailed flap, all portions of the flap being attached to the same pedicle. This can be done only when the deformity exists at the temporal portion of the lid and the socket. The author recalls a case in which there was a loss of the outer temporal portions

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FIG 197.—The utilization of Snydacker's technique *A* shows the original defect, *B*, the elevation of the cervical flap, *C* and *D*, the use of the cervical flap, *E*, resection of the pedicle and suture line to complete the correction

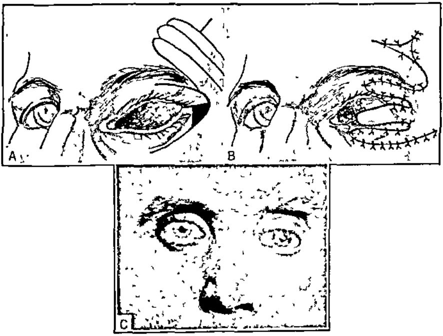

FIG. 198.—The utilization of a multiple flap with a single pedicle Photograph shows the end-result.

dis[illegible] of [illegible] and lower lids. The remaining inferior cul-de-sac was very [illegible] of the loss of tissue in the lower lid as well as because of the [illegible] of scar tissue lying under the skin of the lower lid. While this [illegible] rather unusual, the technique practiced in its correction will be [illegible] here, because from it a method may be suggested to the operator to [illegible] lowed in similar cases.

A large three division flap was cut from the forehead external to and [illegible] the brow, extending well over upon the frontal portion of the forehead. Linear incisions were cut from the base of the pedicle of this flap extending into the upper lid, the outer canthus, and then continued into the inferior cul-de-sac of the contracted socket. A third incision was made into the outer angle of the lower lid. The incision into the canthus had a small, short, right-angled, lateral incision made downward to allow a better release of the tissues of the lower lid. The small triangle of tissue between these incisions when completed was resected and discarded (Fig. 198). All of these incisions were well undermined. The large flap was then moved downwards and toward the orbit. The upper division was sutured in place in the upper lid in the incision prepared for it there. The lowest division was sutured in the lower lid in the incision prepared there. The middle arm was carried into the socket through an incision from the base of the pedicle through the canthus into the socket. It was placed into position in an area formed by undermining and by the release of the contracted, insufficient conjunctiva. No sutures were used in this middle division of the flap. It was held in its proper place by a mold of gutta percha placed over the flap in the socket. At the outer canthus, this mold folded the flap upon itself in the shape of a letter S so that an adequate cul-de-sac would be formed at the outer canthus. A tarsorrhaphy was performed and maintained for one month to hold this mold in place with a slight amount of pressure. The region from which the flap was lifted was widely undermined and sutured. Dermol was used for these sutures. (As all of the edges could not be brought into apposition, the scar from the uncovered central portion of the trifoliate-shaped suture line was later resected and filled in with a large Ollier-Thiersch graft to prevent late contraction.) The entire field was dressed with paraffin impregnated gauze and was not disturbed for eight days. At the end of that time the dressing and all the sutures were removed. The case was redressed daily for six additional days. There was an adequate am[illegible] of conjunctiva so that the socket would retain a prosthesis, but f[illegible] standpoint the condition could be improved. A free skin [illegible] a mold according to the te[illegible]que of Gillies and Esser, [illegible]l, was used to complete th[illegible]

There is a [illegible] danger of death of a [illegible] ese extensive defects, and [illegible] reason it is wiser to [illegible] t of work at different op[illegible]

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A tube[illegible] times. [illegible] non-tubed pedicle fl[illegible] lower lid, [illegible] enucleate[illegible] of the low[illegible] of

the forehead. All scar tissue must be first removed so that a long rectangular defect or area appears. Then a flap should be cut from above the brow with its pedicle at the junction of the nose and the forehead. The pedicle is tubulated and moved downwards, at the same time twisting it. It is sutured into the upper edge of this denuded area with a dermol intradermic suture. The ends of this suture should be allowed to extend ⅓ inch from either end of the flap. This flap has been turned so that its epithelial sur-

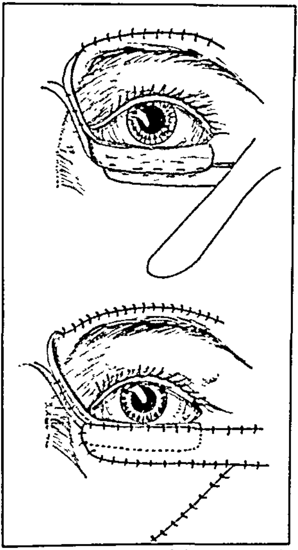


Fig. 199.—Double flaps, one tubed, the other a simple flap.

face will now lie innermost, that is, the superior margin of the flap now lies most inferiorly and the inferior margin superiorly. At the outer and inner canthi a few black silk sutures are placed so that there is an accurate approximation of the edges of the flap to the denuded area. The tubulation of the flap should be stopped 1 cm. before the planned level of the new lower lid is reached to prevent kinking and distortion of the terminal part of the flap (Fig. 199). This denuded area, with the subepithelial surface of the above flap presenting and augmenting the amount of denudation,

of both upper and lower lids. The remaining inferior cul-de-sac was very shallow because of the loss of tissue in the lower lid as well as because of the many bands of scar tissue lying under the skin of the lower lid. While this case is rather unusual, the technique practiced in its correction will be related here, because from it a method may be suggested to the operator to be followed in similar cases.

A large three division flap was cut from the forehead external to and above the brow, extending well over upon the frontal portion of the forehead. Linear incisions were cut from the base of the pedicle of this flap extending into the upper lid, the outer canthus, and then continued into the inferior cul-de-sac of the contracted socket. A third incision was made into the outer angle of the lower lid. The incision into the canthus had a small, short, right-angled, lateral incision made downward to allow a better release of the tissues of the lower lid. The small triangle of tissue between these incisions when completed was resected and discarded (Fig. 198). All of these incisions were well undermined. The large flap was then moved downwards and toward the orbit. The upper division was sutured in place in the upper lid in the incision prepared for it there. The lowest division was sutured in the lower lid in the incision prepared there. The middle arm was carried into the socket through an incision from the base of the pedicle through the canthus into the socket. It was placed into position in an area formed by undermining and by the release of the contracted, insufficient conjunctiva. No sutures were used in this middle division of the flap. It was held in its proper place by a mold of gutta percha placed over the flap in the socket. At the outer canthus, this mold folded the flap upon itself in the shape of a letter S so that an adequate cul-de-sac would be formed at the outer canthus. A tarsorrhaphy was performed and maintained for one month to hold this mold in place with a slight amount of pressure. The region from which the flap was lifted was widely undermined and sutured. Dermol was used for these sutures. (As all of the edges could not be brought into apposition, the scar from the uncovered central portion of the trifoliate-shaped suture line was later resected and filled in with a large Ollier-Thiersch graft to prevent late contraction.) The entire field was dressed with paraffin impregnated gauze and was not disturbed for eight days. At the end of that time the dressing and all the sutures were removed. The case was redressed daily for six additional days There was an adequate amount of conjunctiva so that the socket would retain a prosthesis, but from a cosmetic standpoint the condition could be improved. A free skin graft placed over a mold according to the technique of Gillies and Esser, already described, was used to complete the case.

There is a grave danger of death of a part of the flap in these extensive defects, and for that reason it is wiser to do a certain amount of work at different operations.

DOUBLE FLAPS

A tubed flap may, at times, be utilized with a secondary non-tubed pedicle flap, for the reconstruction of the lower lid; only, however, for the lower lid, and especially satisfactory in cases after the eyeball had been enucleated. One pedicle is taken from the tissue at the temporal junction of the lower lid and cheek, the other from the tissue at the nasal portion of

the forehead. All scar tissue must be first removed so that a long rectangular defect or area appears. Then a flap should be cut from above the brow with its pedicle at the junction of the nose and the forehead. The pedicle is tubulated and moved downwards, at the same time twisting it. It is sutured into the upper edge of this denuded area with a dermol intradermic suture. The ends of this suture should be allowed to extend ½ inch from either end of the flap. This flap has been turned so that its epithelial sur-

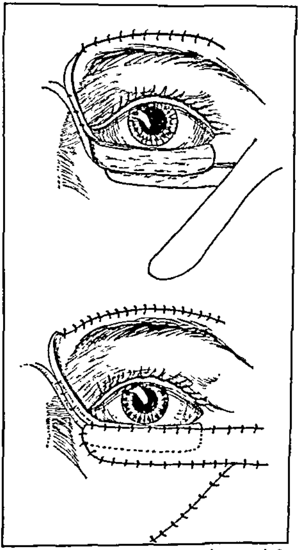


Fig. 199.—Double flaps, one tubed, the other a simple flap.

face will now lie innermost, that is, the superior margin of the flap now lies most inferiorly and the inferior margin superiorly. At the outer and inner canthi a few black silk sutures are placed so that there is an accurate approximation of the edges of the flap to the denuded area. The tubulation of the flap should be stopped 1 cm. before the planned level of the new lower lid is reached to prevent kinking and distortion of the terminal part of the flap (Fig. 199). This denuded area, with the subepithelial surface of the above flap presenting and augmenting the amount of denudation,

is now covered with the second flap from below the lid (see above). It will cause a second scar extending downward over the maxilla-malar portion of the face. The ease, however, with which it is used will almost compensate for this, and if the sutures are carefully placed and massage instituted early, this scar can be made almost invisible. The lower pedicle flap is lifted running from the level of the outer canthus and extending downward over the malar bone at an angle of 45 degrees. This is carefully thinned by the removal of subcutaneous tissues. It is next moved upward to cover the denuded area. Its superior margin is carefully sutured to the now present upper margin of the composite denuded area. The edges of the region from which this flap was taken can be carefully undermined and closed with black silk or with a dermol intradermic suture.

HAMMOCK FLAPS

Another method for the reconstruction of a lower lid and cul-de-sac is somewhat more complicated but the results are invariably good. A flap is cut from above the eyebrow, attached at both ends, in the form of a hammock flap. Both pedicles are tubulated. The central portion of this flap is then sutured in a linear incision made along the level of the upper portion of the remains of the lower lid after all scar tissue has been removed. This is to furnish the skin later needed. Ten days later the pedicles are resected. Three weeks later this area of transplant is lifted at its sides and its inferior edge and rolled upward, so that a cul-de-sac is formed by its original outer surface, now folded upward and inward. The new defect is then covered with a free skin graft held in place by a pressure bandage according to a method previously mentioned. The lid margins are then sutured together with adhesions for a period of eight weeks to three months. A bandage of moderate pressure is applied. This last procedure is best used when there is a minimum amount of scar tissue present, and in female patients because of the minimum amount of operative scarring which results. The factor against it is that three operations are necessary to complete it.

In all of these methods used, a free skin graft from the scalp or from the upper lid bearing a hair line may be placed into the lid margin to restore the cilia. This can be done four to six weeks after the final operation.

In autoplastics with tubed pedicles, Filatov first prepares the pedicle and then three weeks later cuts the correcting apex of this pedicle and moves it into position. He emphasizes a fact illustrated above—the mobility of a flap with a tubed pedicle. The early tubing of pedicle flaps appears worth the effort, at least in flaps of any appreciable size.

In the section which deals with the correction of specific conditions, several other procedures will be described, all of which are the detailed application of these principles.

In applying the dressing for these cases of tubed pedicle flaps from the forehead, it is necessary to place two small gauze rolls upon each side of the pedicle so that the pressure exerted will not interfere with the blood supply coursing through this pedicle. These gauze rolls should be a bit larger than the tube itself and can be wrapped in a small square of oiled silk. A very good plan is to place a third, but longer and thinner roll, against the lower lid, so that accurate approximation is obtained between the surfaces of the two flaps.

SLIDING AND SWINGING FLAPS

Cicatricial obliquity of the palpebral fissure, internal or external canthus downward, due to postoperative defects or to trauma, is correctable by another modification, the sliding flap. In these cases there is almost always an adherent scar present with an ectropion. In some instances these defects almost constitute true colobomata, especially when at the inner canthus.

When the scar is excised an angular flap is outlined. One margin of this is formed below the line of the lower lid, the second by the resection incision and the base of the flap by its attachment. The flap is undermined and raised. It may be necessary to undermine along the margin of the lid to the canthus which lies the higher, so that the flap may be moved without puckering the margin of the lid. A small triangle of skin is next resected from the area of the upper lid at the lower of the two canthi, crossing the canthal bridge of skin down to the skin at the junction of the lower lid and

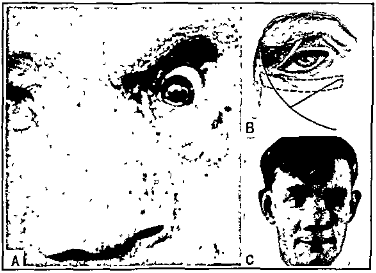


FIG 200 —Sliding flaps *A*, defect, *B*, the technique (and cartilage graft), *C*, the end-result

the bridge of the nose, if at the inner canthus; if at the outer canthus, at a corresponding level. All the deep tissues of both lids should be well released deep into the bony orbit through this excised triangle. This last triangle of skin must lie with its apex upward and outward, so placed that when it is closed the obliquity of the palpebral fissure has been corrected (Fig. 200, *A*, *B*, and *C*). In its closure, this triangle is converted into a line which follows the normal lines of the lid. When this is done the lifted flap is sutured in position, its apex now higher and nearer the mid-line of the face than when it lay in its original site. If the margin of the lid has been excised, one must be careful that the sutures placed there correct any previously existing ectropion. If necessary, this can be accomplished by the resection of a small amount of tissue in a linear manner from the lower conjunctival cul-de-sac and closed with a running dermol suture before the triangular flap is sutured into place. A small triangle, apex down, may be resected from the skin of the lower lid as well at the opposite canthus. One

fact the operator must be careful about, and that is, the position of the sutures. The sutures are placed in the fixed internal lip at a higher level than in the outer lip, and when they are tied the sliding flap will be lifted as well as moved inwardly at the same time.

The angular flap which had been raised below consisting of all of the periorbital tissues is thus drawn up and toward the mid-line. A canthal angle apex suture is placed into the periosteum at the bony nasal-orbital or temporo-orbital line to anchor the flap there. In this way it supports the periorbital tissues which have been twisted upward during the correction of the obliquity. The remainder of the sutures simply coapts the edges without tension. As Imre, of Budapest, states, a good way to correct defects is to use the skin from the immediate neighborhood of the deformity without any real pedunculated flaps. The graft is put into place by sliding the greatest quantity of skin through the shortest possible wound. To do this, he states, curved incisions must be utilized and the tissue used for covering the defect slid in a bow or circle. The curved incision should have the form of a quarter ellipse and be about four times as long as the length of the necessary sliding. At the end of the incision a small triangle of skin, when removed, will make possible an easier sliding and prevent the possibility of a conspicuous wrinkle. In the smaller grafts cutaneous immobilization is adequate, but in the more extensive defects it is often necessary to fix the flaps in their new place with a few buried catgut sutures. The use of catgut sutures is a great help in that they reduce the tension of the skin sutures to a minimum.

In a case where the sliding tissue is cut from the inner corner of the lower lid, Imre always cuts the edge of the flap into two lamellæ. The inner lamella should be fixed to the canthal ligament with catgut sutures, or directly to the deep fascia. This will carry the weight and tension of the flap. The external lamella will thus heal readily. This deep fixation of the flap has always given much less annoyance and more perfect cosmetic results.

In cases of sinus operations, especially into the frontal sinus, in cases of colobomata of the upper lid, and in deep defects of the soft parts and the bony tissue, Imre's methods can be applied with satisfactory results. He calls attention to those difficult cases in which the injury has resulted in a large oval hole in the tissues. (This also applies to postoperative defects after malignancy operations.) Such deformities having no base whatsoever for a sliding flap, one must be made. Imre employs one of the following: he either transplants a piece of fascia from some other part of the body, or in the case of nasal defects, pulls down a bridge of the nasal mucosa. This is followed by undermining the skin and then taking two pedunculated fat and fascia flaps and turning them over the hole. The bridge of mucosa and the turned in tissue are fixed with catgut sutures, then fixed to the pedunculated flaps and these to each other in the same way. In this way, in and about the opening there are three layers of tissue upon which to place the sliding flaps.

A combination of sliding and pedicle flaps with dermo-epidermic grafts is usually successful in the correction of certain defects of the outer canthus. After the scar resection, the incision, and the release of the ectropion, as in a case of oblique scar from the outer canthus over the malar area with cicatricial ectropion, a sliding flap with its apex towards the outer canthus

and the zygomatic region will be outlined, which when sutured upward will leave a triangular defect, apex down, base nearest the lid margin. This can be filled in with a pedicle flap from the temporal region, to give support, or with a free skin dermo-epidermic graft. This same combination was used in the case of the three-tailed flap already mentioned.

WANDERING OR DELAYED PEDICLE FLAPS

Before this section on pedicle flaps can be closed, mention must be made of the wandering or delayed pedicle flap recommended by various men. Filatov, in 1922, described a special ophthalmological case, wherein the method was applied to the correction of a serious ocular defect following anthrax. The pedicle was transferred from the chest in four stages, the blood supply improving at each stage. The pedicle which had shortened during transfer, became longer again when it was flattened out. With each transfer, pedicle and head of flap alternate in the progressive course of transfer. The method has the advantage that no unnecessary skin is used and large scars are prevented; however, it consumes a long time. It lends itself to the correction of very large facial and rhinological defects. In the case of such defects, wandering pedicles may be started from several points at the same time. The author has seen this successfully practiced in the reconstruction of the lobes of the ear.

CHAPTER IX

SURGICAL CONDITIONS OF THE LIDS

Blepharospasm. Pathological Conditions of the Skin, as Xanthomata. Benign and Malignant Tumor Masses, Cysts, Chalazion. Hordeolum (Stye). Blepharochalasis. Baggy Lower Lids

BLEPHAROSPASM

Organic intractable blepharospasm is characterized by a fibrillary twitching involving the orbicularis fibers which gradually increases in intensity and in extent until a tonic spasm results in the complete closure of the eyelids. It should be differentiated from a tic which is a functional involvement of a group of muscles irrespective of nerve supply. True spasm is concerned with an anatomical grouping of muscles having the same nerve supply. Further, a tic disappears during sleep and is influenced by mental states while this is not true of blepharospasm. Gurdjjan and Williams[1] reported improvement in some cases following alcohol injections into the facial nerve. Benedict also feels that alcohol injections into the region of the parotid plexus have the greatest effect upon the branches which supply the frontalis, the orbicularis and zygomatic muscles; hence, least interference with the muscles of the lower face. A cure, however, was effected wherein a neurectomy was done upon the upper two or three branches of the facial nerve. They state that the question of evulsing the peripheral portion of the upper two or three branches of the facial nerve in cases of post-encephalitic blepharospasm, is well worth consideration for a permanent cure.

PATHOLOGICAL CONDITIONS OF THE SKIN

These conditions are almost wholly a matter of tumor masses of the eyelids. Benign tumors, such as telangiectases, while not malignant, have a tendency to become so. The same applies to some papillomata and to many pigmented moles. Xanthomata which appear so commonly in the upper and lower lids at the inner angles are also to be included in this section.

Electrolysis is best used for vascular tumors and for pigmented moles. Either the unipolar or bipolar electrolytic needle may be used. If the bipolar current is used the positive pole is placed upon the back of the neck; the negative pole, the current rheostatically controlled, in the form of a needle is plunged into the tumor and the circuit is closed. Bubbles of gas arising indicate that the tissue is being destroyed. With unipolar desiccation there is fine blue sparking and the tissue is destroyed by the action of the spark at the needle point as the desiccation is being done. This immediate destruction is not so evident with bioplar electrolysis. In this latter instance, the needle is withdrawn from its original puncture, and reintro-

[1] Jour. Am Med. Assn., December 29, 1928

duced several times in different parts of the tumor at the same sitting. The unipolar desiccation acts rather similar to a cautery scalpel. As the coagulation of blood occurs in the vessels as well as in the cell masses of the neoplasm, the tumor mass ultimately disappears. Several separate sittings are always required for the removal of even a small mass. This is not necessarily so with the unipolar desiccation method. The latter of the two, however, demands careful handling, so that the tissue destruction is limited to the confines of the tumor. Both procedures may be rather painful and it is best to use infiltration anesthesia about the tumor and at the base of the tumor. The tumor tissue itself need not be injected.

FIG 201 —Extensive xanthomata

Xanthomata can be treated by this same form of electrocoagulation. If they are larger, however, than 3 x 6 mm., it is best to excise them surgically. The incisions should extend beyond the limits of the yellow masses; they should be crescentic in shape and cut to have their long axis and the concavity of the crescent parallel to the eyelid margin. After sufficient undermining to prevent deformity, the defects can be closed quite readily with fine silk sutures placed intradermically and untied. Figure 201 illustrates a rather severe degree of xanthomata, long standing, but quite readily removed by skin resection. The incisions in this type of case are to be crescentic and parallel to the normal line of the orbicularis fibers, hence closure is made without any resulting deformity. A slight amount of undermining of the contiguous skin is wise, but in some instances this is not wholly necessary.

Pigmented moles, especially the hairy pigmented moles, which occur in the lower eyelid near the outer canthus, may be treated with radium or by roentgen therapy. In such instances a permanent depilation occurs with some slight depigmentation and with some flattening. The advisability of

this treatment is questionable. Electrocoagulation is preferable if the mole is of such a size that this can be carried out. If not, then preliminary roentgen-ray or radium treatment should be used as a precaution against the dissemination of premalignant cells and thereafter the mole should be resected and the raw surface closed with an Imre sliding flap or a free skin graft. If it is necessary to remove both the skin and the conjunctival surfaces, more extensive surgery is necessary. This will be covered somewhat later in this section. In general, it is a good surgical practice not to resect pigmented moles before they have been irradiated as a preliminary precaution.

MALIGNANT GROWTHS OF THE EYELIDS

(See Chapter XXVI on Malignancy)

The treatment of these is somewhat in controversy. In various clinics a wide surgical resection is done, sliding or pedicle flaps then used for closure of the defect, and after complete healing, radium or roentgen-ray treatment is applied to the operative site. This therapy will kill a pedicle flap if

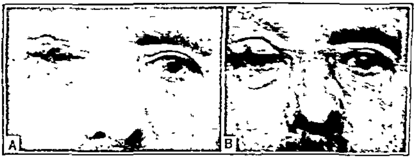


Fig 202 —Malignancy of the upper lid, resected and defect closed with a simple pedicle flap.

applied too early in the stage of recovery. Figure 202 is a successful instance. A clean resection of the malignancy was possible and a tongue-shaped pedicle flap above the eyebrow was used to close the defect. There was no conjunctival defect in this instance and the result was permanent and satisfactory. Imre's procedure,[1] which is to use a sliding flap is especially applicable to the correction of many palpebral defects. The essentials in their use are the clean resection of the neoplasm; the mobilization of the sliding flap; and the subsequent movement of this flap into its correcting position by the assistance of the resection of triangles at the extremity of the incisions. Rather recently Imre has made quite a modification in the shape of these Burow's triangles. Katz[2] discussed this. Instead of an equilateral triangle the apex is rounded and the side of the triangle nearest the defect curves gracefully over into the line of incision. This allows a greater displacement of the flap toward the defect which it is to cover and a smoother closure. Figure 203 illustrates these flaps in general, the mobilization of the sliding flap, and the utilization of the triangles. Figure 204, *A*, *B*, *C*, illustrates the correction at the outer canthus. Figure 205, *A*,

[1] Imre, Jr., Lidplastik und plastische Operationen anderer Weichteile des Gesichts, Studium Verlag, Budapest, 1928.

[2] Arch. Ophth., 12, 226, August, 1934.

B, C, shows the correction of a similar condition at the inner canthus. Figure 206, A, B, C, shows a sliding flap correction of a neoplasm of considerable extent close to the mid-line of the lid. This last was a case of angioma. The principle of his sliding flap applies to all cases, however, regardless of their position. Imre's technique is to excise the lesion of the eyelid so that the effect produced is roughly triangular. The incision for the flap to cover this defect, begins at the base of the triangle in a bow shape.

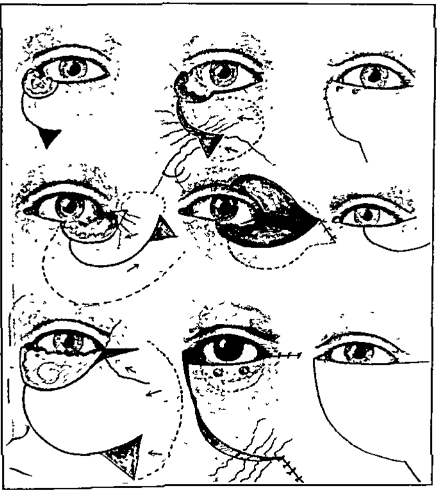


FIG. 203 —The use of sliding flaps. In the lower row is a case of tarsus-conjunctival graft from the upper lid to reform the lower cul-de-sac [2]

The Burow's triangle is then incised at the end of the incision. Imre believes that the narrower the defect the greater should be the radius of the incision. In circular defects, see Figure 205,[1] the incision used is curved so that the width of the flap equals the diameter of the defect and the incision terminates almost on the same plane as the upper limits of the defect. Imre found that by undermining the skin on the side of the incision opposite

[1] Figures 203 through 206 Imre. Lidplastik und plastische Operationen anderer Weichteile des Gesichts, 1928

[2] Katz Plastic Surgery of the Eyelids with special reference to the Hungarian School, Arch. Ophth., 12, 226, 1934.

to that of the flap, but leaving the upper side of the Burow's triangle adherent to the underlying tissue, he was able to readily cover large defects. This principle is well illustrated in the figure. The flap is moved so as to cover the defect, and the undermined skin edges are readily approximated to the flap when the Burow's triangle is sutured. The flap itself is then sutured in place by obliquely placed sutures to cover the defect without tension.

Blaskovics and his followers utilize Siklösy's technique largely for the repair of defects of the eyelids which result from excision of neoplasms. Siklösy's original procedure was a straight incision down and out from the

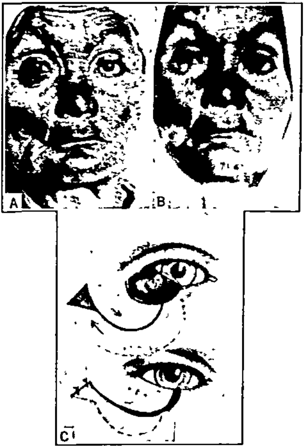


Fig 204 —Malignancy at the outer canthus.

inner angle for the correction of ectropion. Undermining of this incision under its lateral lip and then closure by obliquely placed sutures raised the mobilized lip of the wound to correct the ectropion. The Blaskovics modification of this is shown in Figure 208, *A* and *B*, wherein, by a combination of triangular resections at the two ends of the incision line, mobilization and elevation of the skin is made possible. Imre's technique is also applicable to an upper lid malignancy. In these cases clean surgical resection may be utilized; also electrocoagulation is to be considered. If a portion of the conjunctiva is lost, this loss must be corrected in some other manner. Figure 211 is a cicatricial defect resulting from malignancy resection and

subsequent radiation, with a conjunctival loss in the coloboma seen. In this case the conjunctiva could not be adequately mobilized for the correction of the coloboma according to the technique which is mentioned under that section. In this instance a mucous membrane pocket had to be made in the skin of the cheek of the lower lid. Ten days later the scar running into the eyebrow was resected; the tissue of the upper lid was removed from the nasal lip of the coloboma to the canthal angle; and a pedicle flap was moved into this secondary defect with its mucous membrane covered, posterior surface, correcting head, sutured into the surgical defect thus formed. In this manner, the posterior surface of the lid was

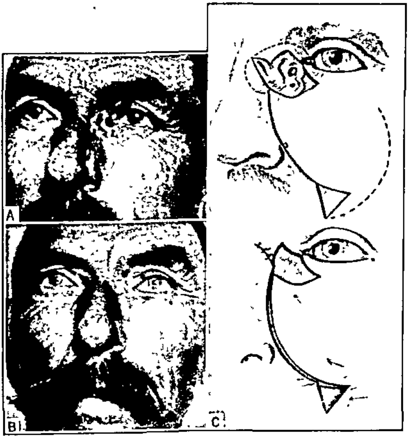


FIG. 205 —Malignancy at the inner canthus

covered with the mucous membrane and the anterior surface with skin from the lower lid and the cheek. The mucous membrane pocket is formed (see Mucous Membrane Grafts) by burying, beneath the skin of the cheek, a small flat rectangular plaque of stent of a size equivalent to the surgical defect which will be present in the lid. A mucous membrane graft had been wrapped about this, epithelial surface innermost, and subsequently dressed with a pressure dressing. After eight days this graft dressing may be removed, the sutures taken out, the skin incision reopened, the rectangular plaque removed, the pocket irrigated, and the plaque again replaced as a splint to maintain the pocket satisfactorily until it is utilized. The flap,

with its mucous membrane and skin covered head, is carried into a correcting position ten days to two weeks later. After such a pedicle flap has been carried into the upper lid, a square of mucous membrane will remain upon the surface of the cheek, this being originally the posterior surface of the

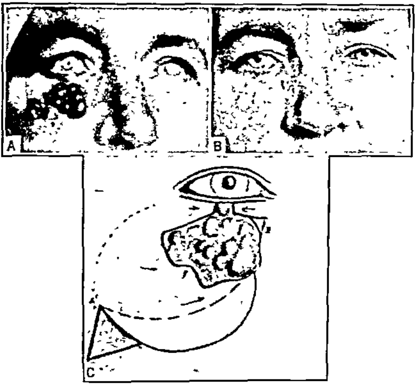


FIG 206 —Malignancy at the mid-line of the lid.

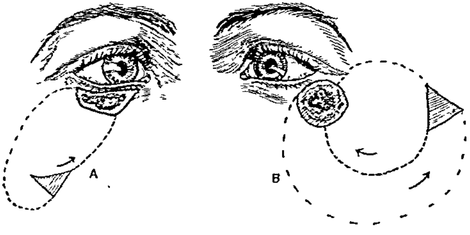


FIG. 207 —Imre's technique for a circular defect; *A* and *B*, compare the undermining necessary for this and for a simpler defect. (Katz, Arch. Ophth., 12, 226, 1934)

pocket formed. This should be dissected out and discarded because it will be conspicuous. It can be grafted flat with an Ollier-Thiersch graft or filled in with the skin which had been removed from the upper lid in preparing the secondary defect there for the pedicle flap.

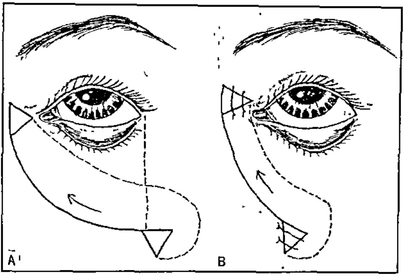


FIG 208 —Blaskovics modification of the Siklösy incision *A*, original Siklösy incision, *B*, Blaskovics modification of it (Katz)

FIG 209 —Case showing utilization of the technique illustrated in Figure 208, *A* and *B*. (Sutures still in place)

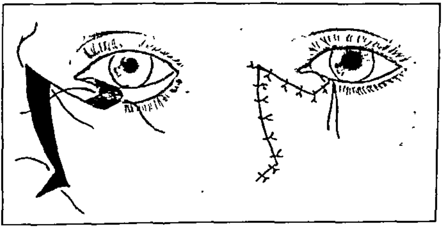


FIG 210 —A second application of Blaskovics modification of the Siklösy incision for the correction of ectropion, surgery being done at the nasal angle (Elschnig, Handbuch der gesamten Augenheilkunde, courtesy of Julius Springer.)

The important factors in the treatment of malignancies of the lid from a surgical standpoint are: (1) an early diagnosis; (2) careful examination as to the possibility of metastases into the glands connected with the lymph drainage of the eyelid; (3) careful consideration as to the plan of treatment to be carried out as: (a) electrocoagulation, (b) the use of radium or roentgen therapy, and (c) surgical removal, plastic correction and, in conjunction with these, later, radium or roentgen therapy. In general, the eyelid margin must be left intact if possible. The conjunctiva of the upper lid cannot be mobilized, however, due to its firm adherence to the tarsal plate.

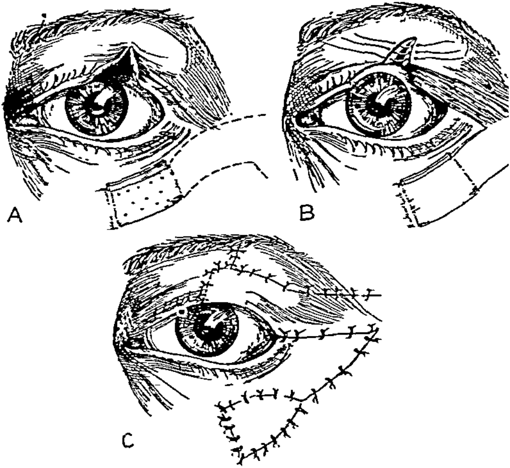


Fig 211 —Mucous membrane and skin pedicle flap correction for a postmalignancy defect (Courtesy of Jour. Am Med. Assn)

If the tarsal plate must be resected a procedure similar to that in Figure 272 must be carried out. The muscle of the orbicularis should be disturbed as little as possible. Any deformity remaining at the time of the plastic correction will, in the course of healing, become aggravated. Secondary operations are, therefore, not at all uncommon. Figure 212, *A*, *B*, *C*, is an ectropion following desiccation for malignancy corrected by a pedicle flap from the forehead with intermarginal adhesions and their subsequent release. Figure 213 is a similar case, though in this a full thickness lid flap was utilized.

Abscesses of the upper and lower lid are not uncommon. They should

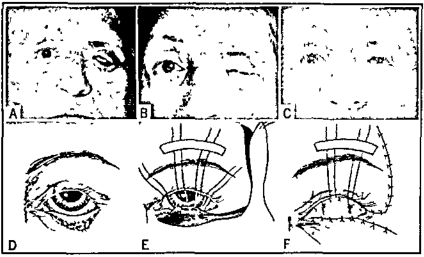


FIG. 212.—*A*, *B* and *C*, post-malignancy ectropion corrected by a pedicle flap with a median tarsorrhaphy. *D*, *E* and *F* illustrate the technique for the correction.

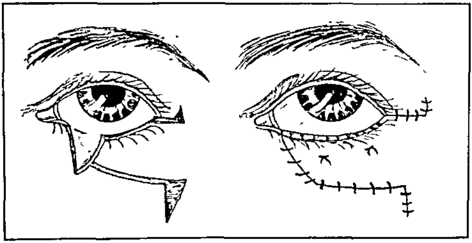


FIG. 213.—Basal cell carcinoma corrected by resection and a full lid thickness flap.

tangled mass of pearly white fibers has been resected, a certain portion of the redundant skin may be removed and the skin wound closed with interrupted silk sutures. The amount of redundant skin which is to be resected can be readily gauged by picking up the skin edge with grasping forceps and moving it up to the incision line and beyond it. The overlapping of the mobilized skin beyond the incision line gives the operator an idea of how much may be safely removed at this time. At times this redundancy of epithelium may reach enormous proportions. In some instances this redundant skin is quite hairy. In these cases the roentgen-ray has its sole value in neurofibromatosis, that of acting as a depilatory. A pressure dressing must be applied to prevent the almost-certain bloody serum seepage which will occur in these wounds as a result of the extensive resection and the inevitable trauma to the tissues. As soon as healing has occurred, the resulting ptosis must be corrected by some plastic method.

FIG 214 —Neurofibromatosis

Utilization of the levator is impossible, and the unilaterality of the case prevents the use of any modification of the Moti operation. The ptosis in Figure 214, A, was corrected by means of the Hunt-Tansley procedure, and that in Figure 214, C, was improved appreciably by further resection of the lid tissue and the utilization of a Snellen suture tied above the skin of the forehead through a pearl button. The middle photograph (*D*) was taken before the sutures had been entirely removed. There is some temporary edema still present in the skin about the lid and the forehead. Many *of these cases also need a cartilage graft to elevate the depressed (and frequently* amblyopic) eye to a normal level; a depression due to the enlargement of the orbit from atrophy of its bony walls and floor.

A tendency for the lid margin of the upper lid to turn out in a slight ectropion following these extensive resections can be corrected by mattressing three sutures from the conjunctiva through the entire lid substance and tying them upon the surface of the lid through tiny perforated rubber

plates. Their presence causes a cicatricial adhesion in the superior fornix high up behind the upper lid, and the deformity is thus completely corrected.

HEMANGIOMA. LYMPHANGIOMA

Hemangioma and lymphangioma respond, in part, to roentgen-ray and to radium. MacDonald,[1] Bock,[2] and von Liebermann[3] all report the use of radium therapy for these conditions. Marque[4] considered this treatment *to be ideal when the angiomata were in the orbital cavity.* *Reference has*

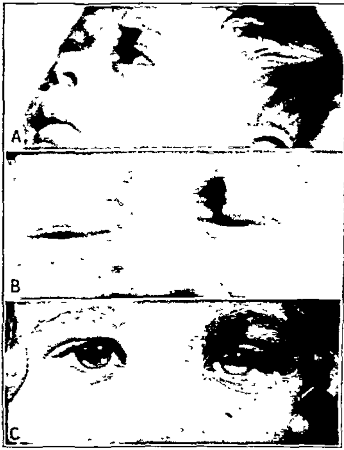
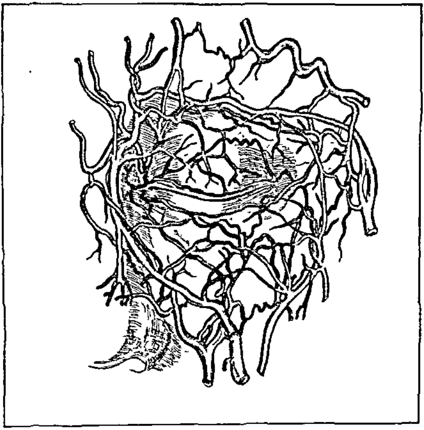


FIG. 215.—Hemangioma shortly after birth, six months later, and four years later. Histopathological diagnosis at this time was pigmented basal cell carcinoma.

been made to this in the chapter on Orbital Pathology, in discussing roentgen-ray therapy for pulsating arteriovenous aneurysm. This applies especially to the hemangiomata. It is rather common, however, to find that plastic surgery is necessary in addition. Hemangiomata which fail to respond quite promptly to roentgen therapy are to be considered malignant (basal cell carcinomata) and are then to be removed by electrodesiccation—a portion being conserved for postoperative histopathological study. Figure 215 is such a case, wherein the sequence of events was as just described.

[1] Am. Jour. Ophth., 10, 349, 1927.
[2] Wien. klin. Wchnschr., 2, 1199, 1462, 1931.
[3] Klin. Monatsbl. f. Augenh., 69, 280, 1922.
[4] Rev. oto-neuro-oftal., 1, 202, 1927.

PLATE I



The arterial and venous systems of the upper and lower lids.

Two years after the time at which this illustration was taken, histological study of the lesion after complete surgical removal showed this form of malignancy. The large scarlet and wine-red hemangiomata seen frequently on the face are not an ophthalmological problem. The extensive plastic surgery connected with these had best be done by a facial plastic surgeon. Fractional correction is so often necessary when they are of any great extent, and he is usually well qualified to take care of that portion of the hemangioma which extends upon the lid. Angiomata which are limited to the lid itself and do not extend over onto the skin of the face are properly taken care of by the ophthalmologist. The small superficial ones can be corrected with fair results by electrolysis. Geronimi, Worms,[1] and others have been quite satisfied with this treatment. Rather recently various forms of sclerosing solutions consisting of quinine and of urea hydrochloride have been recommended. The author has used this with most satisfactory results. Before this solution had been recommended, alcohol injections were used, and formaldehyde and boiling water. Weekers[2] reported the successful treatment of a retrobulbar varicocele by the retrobulbar injection of a solution of quinine hydrochloride with ethyl carbamate. Later, Weekers, working with Lapierrie,[3] reported success in 4 patients, in age from several months to twelve years, all with excellent results. Several other authors were equally enthusiastic. Malkin recently published in detail his experiences with 3 cases in which he had used a 15 per cent solution of quinine dihydrochloride. He injected 2 to 3 cc. of a 10 to 15 per cent solution of quinine dihydrochloride, alternating this with several injections of 3 cc. of a 10 per cent sodium chloride solution. These are given into the tumor mass every three or four days, depending upon the reaction of the last one. The injection is given immediately under the skin at first, and later much more deeply into the tumor structure. From 7 to 10 injections are usually necessary. The interval between the injections and the number necessary depends wholly upon the size of the tumor. A 50 per cent dextrose solution has also been used repeatedly as a rather satisfactory sclerosing solution. Apparently it is much more self-limiting in its effect than many of the other solutions that have been used from time to time.

CHALAZION

A chalazion, in the majority of cases, is to be treated as a surgical condition. This is especially so in those not uncommon instances wherein secondary infection occurs within the chalazion. When more than one is present within the lid at one time, multiple operation should be done. In children and in the aged the procedure should be done in an operating room. This applies also to those larger cysts wherein sutures will be necessary. They may be extirpated through the conjunctival surface or through the skin surface. The condition, which is a cystic degeneration of a Meibomian gland, must be completely removed—sac as well as its contents. In some instances, the very small ones may be incised and the sac destroyed with either actual cautery or with some cauterizing solution as 5 per cent silver nitrate solution or by glacial acetic acid. When these are used, one must

[1] Arch d'ophth, 43, 733, April, 1926
[2] Arch d'ophth., 50, 369, 1933
[3] Bull Soc. belge d'ophth, 68, 23, 1934, Arch. d'ophth., 52, 14, January, 1935.

be careful that they are applied on tightly wound applicators and that the effects of the application are limited wholly to the sac membrane. Needless to say, neutralization of the excess must be done immediately after the withdrawal of the applicator. If the sac wall is not destroyed or removed in its entirety the chalazion will quite likely reform.

The size and position of the chalazion and the amount of thinning of the overlying tissues decides automatically whether one should remove it through the skin surface or through the conjunctiva. In general, the larger cysts should be removed through the skin. Novocain anesthesia is adequate except in children, when gas must be used. Ballooning out the inferior cul-de-sac with a 0.5 per cent solution of novocain is sufficient for the lower lid conjunctival incision, though the instillation of 3 or 4 drops of a 4 per cent cocain should precede the injection. An injection into the superior cul-de-sac is sufficient for most upper lid chalazia. Here, however, the anesthesia is effective as block anesthesia rather than by direct infiltration anesthesia. In addition to this it may be necessary to inject a few drops into the cyst itself, and into its base. If the skin surface is to be incised, infiltration anesthesia with a 1 per cent novocain solution will be necessary. A chalazion clamp forceps is placed over the chalazion, the cyst itself projecting through the ring side of the clamp. This immobilizes the lid, protects the reverse surface, and most important of all, renders the operation quite bloodless.

The forceps is necessary for a satisfactory extirpation by sharp dissection. The parallel bars of the forceps devised by Bailey[1] are sufficiently long to include in their bite the inferior and superior arterial arches which constitute the main blood supply of the main portions of the lid, and the 2 mm. stop eliminates any undue compression of the lid border and renders the application of the forceps quite painless. Recently, Heath[2] also presented a chalazion forceps which was designed for this same reason. Both of these types of instrument permit ready accessibility to a chalazion, that is, one either marginal or proximal thereto, and at the same time both are sufficient in size for even the largest chalazion. The latter of the two forceps is now being used constantly by the author. If the cyst is to be removed through the skin, the incision should lie parallel to the margin of the eyelid. If it must be removed through the conjunctival surface of the eyelid, the incision should be made perpendicular to the eyelid margin. In this way less damage is done to the tarsal plate and to the remaining normal Meibomian glands. Also a vertical incision closes quite readily without sutures. The skin surface incision can be closed with two or three fine black silk sutures. (Wiener makes a crucial incision, and removes the tiny triangles of tissue formed by snips with scissors.) As soon as the clamp is applied, an incision of adequate length is made directly over the chalazion without cutting into it, if this is possible. The cystic tumor may be cleanly removed with conjunctival forceps and sharp scissors. Care should be taken not to destroy normal tarsal plate tissue. Further, there is a possibility of perforating the lid during the removal of the cyst. If the cyst is accidentally incised it is of no great consequence; one should, however, be most careful in such instances to do a complete removal of the sac wall. Dr. Fred. S. Thorne recently devised and presented a series of graduated burrs,

[1] Am. Jour Ophth., Series 3, vol 15, September, 1932.
[2] Trans. Section Ophth. Am. Med. Assn., 1936.

rather similar to dental burrs, though considerably larger and on longer handles for currettage in these cases. They work very nicely in completing a total removal of the chalazion.[1] A twenty-four-hour dressing is usually necessary for those which have been removed through the skin surface. A bland eye wash frequently applied is adequate, postoperatively, for those removed through the conjunctival surface.

Recurrent chalazion in individuals past middle age and especially the aged, always should be considered as possibly malignant. Electrodesiccation removal and biopsy, if possible, are recommended rather than surgical resection in these instances.

HORDEOLUM

This, especially when recurrent, is rather likely due to an uncorrected refractive error. That must be corrected. In children, a nutritional problem may be at fault, in part. Isolated areas of suppuration should be incised through the skin, and infected hair follicles drained by removal of those cilia. Pressure by squeezing and curettage are deplored, because of the possibility of extension to the venous pathways into the cavernous sinus. Incisions at the inner canthi must not damage the canaliculi nor the puncti. Ointments of yellow oxide of mercury, of cod-liver oil, and of brilliant green are frequently recommended. Antistaphylococci bacterial sera and phages are frequently quite successful.

BLEPHAROCHALASIS

Blepharochalasis is an atrophic degenerative condition of the skin of the upper lid as it lies about the orbito-palpebral fold. The condition may become so extreme that the lid margin will overhang the palpebral fissure. It is due to progressive atrophy of the epithelial and subepithelial layers. It is rather likely that the condition is originally an allergic situation, recurrent, extending over a period of many years wherein the patient has at repeated intervals an angioneurotic-like edema of both the upper and lower lids. The brawny edema may recede almost to the normal to reappear without apparent reason, ultimately to end in the atrophic condition which characterizes this disease. In many instances a simple removal of the redundant skin and subsequent suturing of this wound is sufficient One can grasp the atrophic fold with a pair of forceps in each hand, and by stretching the skin determine the amount which must be resected. After the amount of skin resection necessary for correction has been gauged, the fold of skin can be released and removed with a scalpel. A scissors removal will not give as even a resection wound for subsequent suturing. The fibers of the underlying orbicularis must not be damaged.

The sutures which are placed thereafter should either be of a fine dermol, intradermic, or be interrupted sutures of very fine black silk; each suture taking in a very tiny bite of the lips of the wounds. As many as are needed should be used. In all of these corrective skin conditions about the lid, it is wise to remove the sutures as soon as is possible. Intradermic sutures need not be retained more than four days, under ordinary circumstances, and interrupted sutures should be removed—the alternate ones on the third day and the remaining ones on the fourth day after the operation.

[1] Made by Codman & Shurtleff, Inc., Boston, Mass.

In some instances if they are carefully removed this can be advanced one day so that all sutures are out on the third day. A thin film of collodion-impregnated cotton is a rather satisfactory dressing for these cases after the first postoperative dressing has been removed. It is inconspicuous, supportative, and does protect from a secondary infection. The writer has found in these cases of blepharochalasis that if the margins of the incisions are wiped very lightly with the actual cautery before the intradermic suture is introduced, a tendency to recurrence is minimized. The scar in such instances may be a bit more conspicuous, but if attention is paid to curving the incision line in a concave-convex crescent parallel to the curvature of the lid, lying well up in the recess of the orbito-palpebral fold, the subsequent scar will be of no concern.

The principles of the operating procedures necessary for this condition, (at times in part, with other more extensive cases, in their entirety), as described by Hotz and Blaskovics are—excision of an adequate amount of the flabby skin with the removal of prolapsed fat and tear glands when present; attachment of the lower skin margin to the anterior surface of the

FIG. 216 —Blepharochalasis before surgery and forty-eight hours after surgery. Quilting of sutures through upper and lower lids.

tarsus; advancement of the relaxed levator tendon if necessary; and reinforcement of separated and stretched tissues of the septum orbitali by separate sutures to the periorbita. Figure 217, *A*, *B* and *C*, illustrates a case of Keith Kahn's[1] before and after treatment. He uses a special clamp for holding the redundant skin.

Figure 216 is a rather classical case of blepharochalasis in both the upper and the lower lids. This figure illustrates the suture line, twenty-four hours after the surgery. It shows very well the smoothly lying skin now in a correct position away from the lid margins, especially in the upper lid, moved back to the superior orbital palpebral fold and there quilted into position.

A condition rather similar to blepharochalasis is the redundant, relaxed, and oftentimes discolored pouch which lies in the lower lid. It is quite distressing as a cosmetic blemish and for this reason should be corrected whenever possible. The operation spoken of as lid rhytidectomy, by Hunt, is necessary for this correction. It utilizes a crescentic resection of the

[1] New York State Jour. Med., 34, 781, September, 1934

redundant skin with small wedges from the outer angle or from both outer and inner angles to take up the fulness there. Hunt uses a clamp which picks up all the redundant skin for easy resection. Figures 218 to 221 show the application of this clamp, and a case of Hunt's before and after operation with his sketch of the area of skin resection and undermining

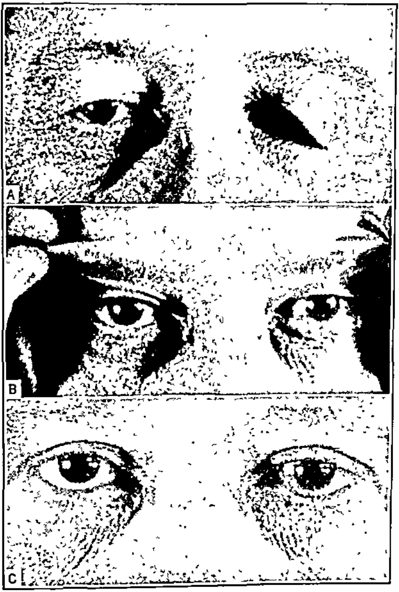


FIG. 217.—Blepharochalasis before and after surgery (Kahn, courtesy of New York State Jour Med)

before the intradermic suture has been placed. Miller[1] calls attention to the absolute necessity for placing the sutures in the closure of these wounds with only sufficient tension to draw the skin edges together without gaping. Tightly tied stitches will mark the skin here, most decidedly, even if they

[1] Cosmetic Surgery, F. A Davis Company, pp 30 and 32, 1924.

CHAPTER X

SURGICAL CONDITIONS OF THE LIDS—CONTINUED

DISTURBANCES OF THE PALPEBRAL FISSURE. ANKYLOBLEPHARON. CICATRICIAL NOTCHING OF THE LIDS. LOSS OF CILIA. SINUSES ABOUT THE CANTHI. TEMPORARY AND PERMANENT TARSORRHAPHY. OBLIQUITY OF THE PALPEBRAL FISSURE. CANTHOTOMY AND CANTHOPLASTIES. COLOBOMATA. EPICANTHUS. THE SURGICAL TREATMENT OF LAGOPHTHALMOS. EXOPHTHALMOS, ENOPHTHALMOS. ATROPHY OF THE RETROTARSAL TISSUES OF THE UPPER LIDS.

DISTURBANCES OF THE PALPEBRAL FISSURE

DISTURBANCES of the palpebral fissure include ankyloblepharon, the loss of the cilia, cicatricial notching of the lid margins, temporary and permanent tarsorrhaphy, and obliquity of the palpebral fissure.

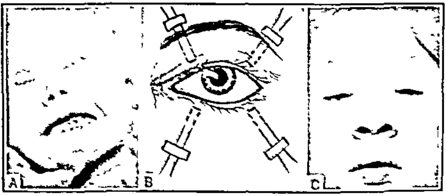
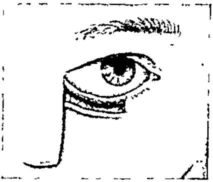


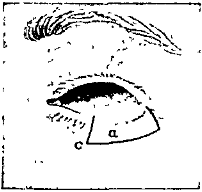
FIG. 223. Ankyloblepharon. *A*, before operation; *B*, the technique of the surgery; and *C*, the case eight months later.

Ankyloblepharon. Ankyloblepharon is a rather uncommon condition but quite readily corrected. The lid margins must be incised and sutured thereafter, conjunctival to epithelial surface. Very fine black silk sutures on fine needles are necessary. A preliminary overcorrection is advised. After the conjunctival sutures are placed, four light silk sutures are to be mattressed in the two angles of the palpebral fissure and anchored, after the operation, to the forehead above and to the cheek below for forty-eight hours to prevent the development of adhesions. Naturally, the eye must be dressed with a Buller's shield filled with sterile white petrolatum as is common for ptosis operations. These cases are usually accompanied by ptosis and occasionally by epicanthus as well. These latter defects are to be corrected at some later time. Figure 223 is such a case of ankyloblepharon before and after [illegible]. The ptosis is very evident; *B* illustrates the technic[illegible]

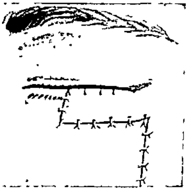
margin plastics, Axenfeld is very fond
partial defect of the lower lid (Fig. 224,
'ct, however, which involves the major



B



D



F

's modification of a Fricke flap [1]

bridge or hammock flap as in Figure
ng pedicle flap is first outlined and

en Erfahrungen im Weltkrieg, Band 5 Augen-
in Ambrosius Barth, Leipzig, 1922.

FIG 218 —Bagginess of the eyelid. (Hunt.)

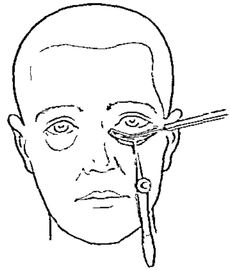
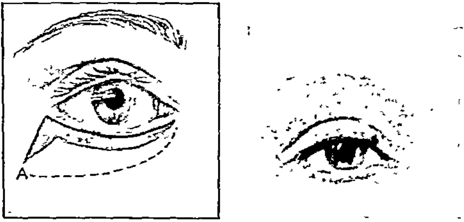


FIG 219 —Hunt's method of removing redundant skin (lid rhytidectomy) from the eyelid by use of Hunt's clamp (Hunt.)



A *B*

FIG 220 —Hunt's method of removing redundant skin from lower eyelid. *A*, area of undercutting. *B*, after operation. (Hunt.)

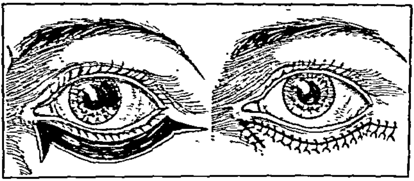


FIG. 221.—Resection and suture. (Courtesy of F. A. Davis Company.)

are removed within forty-eight hours. Carefully placed stitches, properly tied, may remain three to four days without causing stitch marks. This is sufficiently long to allow primary union. Figure 221 illustrates the resection and the suture.

EPIBLEPHARON

This condition, first described in any great detail by Czermack, and somewhat later by Pillat, is a congenital defect, to be considered surgically as an incomplete form of epicanthus. A redundant fold or hammock of skin lies in the lower lid 1 mm. or more from the line of lashes, in a smooth, cyst-like elevation, occasionally with a sharp upper margin The condition should not be operated before the fifteenth year because these conditions seem to improve very definitely during the growing years of the child's life.

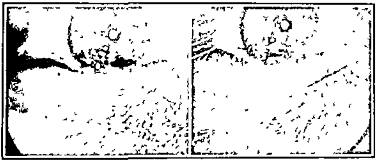


FIG. 222.—A well outlined case of epiblepharon in stereoscopic view (Dr Charles Young personal communication)

The residuals, at that time, may be resected, skin and orbicularis fibers, in a longitudinal manner, the tissue removed being of a spindle shape, and the defect closed in two layers, the orbicularis fibers with No. 6-0 plain catgut, and the skin closed with an intradermic dermol suture Some trichiasis may be present in the very early years of life. This trichiasis, so frequently present, may be severe enough to make earlier surgery obligatory Figure 222 is a case of Dr. Charles Young's, mounted as stereoscopic views so that this condition can be more easily seen.

CHAPTER X

SURGICAL CONDITIONS OF THE LIDS—Continued

Disturbances of the Palpebral Fissure. Ankyloblepharon. Cicatricial Notching of the Lids. Loss of Cilia. Sinuses About the Canthi. Temporary and Permanent Tarsorrhaphy. Obliquity of the Palpebral Fissure. Canthotomy and Canthoplasties. Colobomata. Epicanthus. The Surgical Treatment of Lagophthalmos, Exophthalmos, Enophthalmos. Atrophy of the Retrotarsal Tissues of the Upper Lids.

DISTURBANCES OF THE PALPEBRAL FISSURE

Disturbances of the palpebral fissure include ankyloblepharon, the loss of the cilia, cicatricial notching of the lid margins, temporary and permanent tarsorrhaphy, and obliquity of the palpebral fissure.

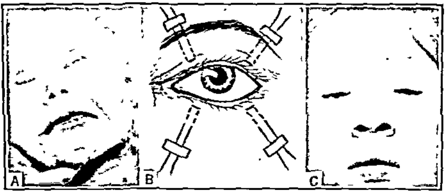


Fig. 223.—Ankyloblepharon. *A*, before operation; *B*, the technique of the surgery; and *C*, the case eight months later.

Ankyloblepharon.—Ankyloblepharon is a rather uncommon condition but quite readily corrected. The lid margins must be incised and sutured thereafter, conjunctival to epithelial surface. Very fine black silk sutures on fine needles are necessary. A preliminary overcorrection is advised. After the conjunctival sutures are placed, four light silk sutures are to be mattressed in the two angles of the palpebral fissure and anchored, after the operation, to the forehead above and to the cheek below for forty-eight hours to prevent the development of adhesions. Naturally, the eye must be dressed with a Buller's shield filled with sterile white petrolatum as is common for ptosis operations. These cases are usually accompanied by ptosis and occasionally by epicanthus as well. These latter defects are to be corrected at some later time. Figure 223 is such a case of ankyloblepharon before and after correction. The ptosis is very evident; *B* illustrates the technique as outlined above.

Lid Margin Plastics.—In the lid margin plastics, Axenfeld is very fond of Kuhnt's use of a pedicle flap for a partial defect of the lower lid (Fig. 224, *A*, *B*, *C*, *D*, *E* and *F*). (For a defect, however, which involves the major

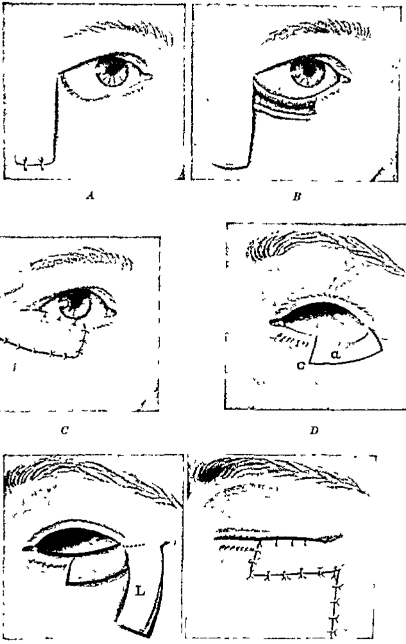


Fig 224—Utilization of Kuhnt's modification of a Fricke flap[1]

portion of the lower lid he utilizes a bridge or hammock flap as in Figure 225, *A*, *B*, *C* and *D*.) The correcting pedicle flap is first outlined and

[1] Figures 224–225· From Handbuch der ärztlichen Erfahrungen im Weltkrieg, Band 5 Augenheilkunde von Prof Dr Axenfeld, Verlag Johann Ambrosius Barth, Leipzig, 1922.

lifted (Fig. 224, *A*). The defect beneath it is grafted flat, a hinge of oiled silk placed over the flat Thiersch graft, and the head of this flap returned to its original position for a time with a pressure dressing. The lid defect is then opened as seen in *B*, by an incision beneath it, a distance equal to the depth of the defect, and this hinge turned upward by sharp dissection, forming thereby a posterior surface for the flap. This flap is now released (after the graft beneath has taken, eight to ten days later) and is moved

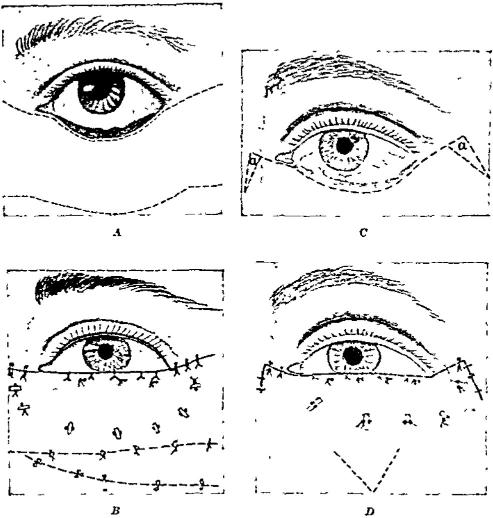


FIG 225 —Utilization of Kuhnt's bridge flap for lid margin defect. *D* is combined with a cartilage-conjunctival graft on its posterior surface.

upward into the operative defect just formed. The upper level of the flap should be 2 to 3 mm. higher than is the level of the normal lid to permit later inevitable contraction of the flap. If the defect is of an appreciable size, a piece of ear cartilage may be buried in the skin of this flap for maintaining rigidity therein, this to be done before the flap is moved into a correcting position. In Figure 224, *D*, *E* and *F*, an operative defect which involves at least one-half of the lid surface and margin is corrected as illustrated, but this must be accompanied by a previously buried piece of

ear cartilage into the skin which is to form the flap. Eight to ten days after the buried cartilage graft, the scar, etc., may be resected and the defect closed as outlined in *F*. If the conjunctival surface is also lost, this must be replaced. If there is no eyeball present, the raw surface of the flap may be grafted after its transfer by a Thiersch graft over a mold, and this placed into the socket at the same time; or the flap may be grafted upon its posterior surface before it is transplanted, and after the cartilage is buried. If the eyeball is still intact, the flap must be prepared with a similar conjunctival or mucous membrane graft, or a mucous membrane or conjunctival plastic done at the time when the flap is moved up into a correcting position.

In the bridge flap of Kuhnt, the initial incision passes from the outer canthal angle to the inner, at the most anterior limit of the area of lid pathology, externally directed upward at an angle of 45 degrees, and internally over the anterior lacrimal crest. A second incision is made 2.5 to 3 cm. beneath this, its central portion parallel to the curve of the first, but horizontal at its ends. A piece of ear cartilage is then cut the size and shape of the tarsal plate: 20 to 24 mm. in length and about 8 mm. in width, at its widest portion. This is cut with intact skin overlying the cartilage for 6 to 7 mm. The lid margin lesion or cicatrix is resected, the conjunctiva from the remains of the inferior cul-de-sac (if such still exists) and from the eyeball is undermined, and then the skin which rims the graft of ear cartilage is sutured to the lower portion of this remaining conjunctiva. The bridge flap is undermined throughout and lifted to its correcting position, and the upper margin of the skin of the cartilage graft sutured to the upper margin of the bridge flap. The bridge flap itself is then anchored firmly into position by sutures (*a*) to the periosteum of the inferior lip of the orbit; (*b*) to the internal canthal ligament anteriorly and posteriorly, and to the periosteum at the lacrimal crest; (*c*) temporally at the outer rim of the orbit to the periosteum and into the upper lid, and (*d*) accurate coaptation of the skin of the cartilage graft to the skin of the flap. The defect which lies beneath the bridge flap is covered with a pedicle flap from the neighboring skin as illustrated. The author utilizes this procedure in many instances with distinct success, grafting, however, first a pocket of mucous membrane beneath the skin of the lid at the site of the new lid margin which is to form the flap, later burying the cartilage into the space beneath this mucous membrane graft and the skin surface, and then proceeding with the classical technique as outlined. This is to prevent the approximation of skin surface to the contiguous cornea—a circumstance to be avoided if possible.

Notching of the lid margin is occasionally seen following the utilization of the levator for the correction of ptosis wherein support to the lid margin has been lost as a result of a necessary earlier tarsectomy. In these instances, no skin tissue is lost, and the patient closes the lids readily. The orbicularis alone, however, is not sufficient to prevent the notching in the mid-line. Figure 299, Section of Ptosis, Chapter X, well illustrates such a condition. They must be corrected, and a very satisfactory return of function with a beautiful cosmetic result can be obtained by replacing the tarsal plate with a slightly oversized plate of ear cartilage. The pinna is folded forward, and a skin incision made upon the posterior surface of the pinna, the skin undermined, the cartilage incised along a line, representin-

the inferior margin of the transplant, without perforation of the skin upon the anterior surface of the pinna. With a blunt periosteal elevator, the cartilage is released from the skin surface. The plate necessarily resected with sharp blunt-pointed scissors is laid to the side, while the skin incision in the pinna is closed with interrupted silk sutures. The lid is then incised in a horizontal manner, half-way between the lid margin and the rim of the orbit. The orbicularis fibers are separated from the conjunctiva and the new tarsal plate placed between the conjunctiva and the orbicularis fibers. These muscle fibers must then be carefully closed with 6-0 plain catgut over the cartilage plate and the skin in turn closed with either interrupted silk sutures or with an intradermic dermol suture.

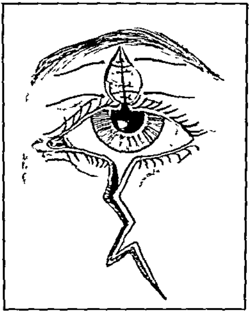


FIG 226 —Fresh laceration of the lid This illustrates Weiner's emphasis that skin be resected about these lacerations so that the skin defect becomes elliptical.

Lid margin defects of the upper lid, by reason of the peculiar anatomical structures there of tarsal plate and adherent conjunctiva, must be handled quite differently. The principles of this are presented under the section on Lid Colobomata, Congenital and Traumatic.

Deformity of the lid margins, that is, a cicatricial incisura, is not a simple thing to correct. The principles underlying its correction are also applicable to the correction of fresh lacerations of the lid margins. The three points of outstanding importance are: (a) a separate suture line for the tarsus and conjunctiva; (b) this (a) suture line separate from that for the skin surface; and (c) widening the skin defect with formation of two very tiny tongues of skin upon the lid margin so that when the suturing is completed there will be a slight pouting of the tissues there to prevent a later notching. If this pouting of the wound continues after full recovery, it is easy to remove the excess of the tiny hillock with the actual cautery. This is illustrated in Figure 226: it being a fresh laceration in the lid margin (or the resection necessary to remove a small cicatricial incisura); illustrates the closure of the tarsus with plain No. 6-0 catgut suture, and at the same time shows the tiny triangles of unequal size resected from the skin at the lips of the wound so that the silk sutures in the skin surface will be offset from the catgut sutures in the tarsus, at the same time, the two small cuts in the skin surface (not including the tarsus) mentioned above are formed. Closure starts farthest from the palpebral margin. As this reached, the two tongues fold outward. A last suture may be placed through them if thought necessary. Figure 227 illustrates an actual case repaired in this manner.

Esser's[1] method of correcting cicatricial notching of the lid is very satisfactory. Figure 228 illustrates his technique which is as follows.

The triangular flap is taken from the upper lid with the apex uppermost and the border of the eyelid for its base. It includes the breadth of the eyelid in height and the whole of it in thickness. About one-third of the length of the eyelid border may be taken, usually from the middle region. A very short, fine pedicle, situated at the lower and outer angle of the triangle, 2 mm. long, *attaches the triangle to the rest of the eyelid. In* addition to the blood-vessels, the pedicle contains a certain amount of

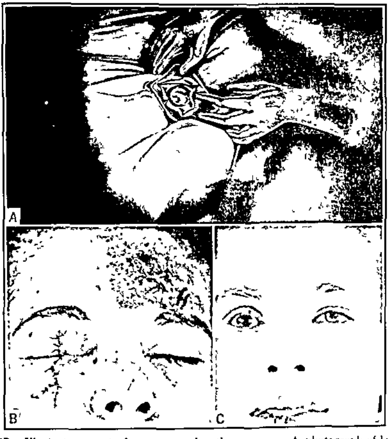


Fig. 227.—Illustrates an actual case repaired in this manner. *A*, photograph of laceration of both upper and lower lids with complete removal of the cornea by the accident; *B*, enucleation and lid sutures; *C*, result four months later, – – – glass eye in position; the lid margins are free of notchings.

connective tissue and a short length of the eyelid border. The presence of the latter in the pedicle is not ideal, but the vessels are so fine and so closely associated with it, that its removal might cause damage to them. Necrosis of the flap does not occur even after it is turned through nearly 180 degrees. In theory it should be turned through 180 degrees, but in practice, owing to the elasticity of the eyelid border, the flap tends to straighten itself again, so that, even when sutured in its new position, it takes up a position at an angle something less than this. In cases where the flap is to be received by and sutured to another flap already brought to the region, the

[1] Revue de Chirurgie Plastique, No. 4, January, 1934.

tissues of this other flap should be chosen with a view to their future function as parts of an eyelid, and they should be as elastic as possible. With the assistance of such other flaps any part up to the whole of an eyelid can be repaired. The new lid need not be as large as the original one, especially as the upper lid with the flap removed is also reduced in size. If the border of the new under-eyelid is comparatively short, the tendency

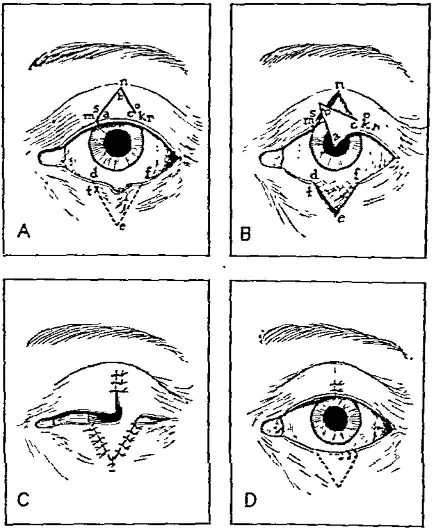


FIG. 228.—Esser's correction for lid notching. *A* and *B*, the initial dissection; *C*, the initial sutures; and *D*, the pedicle of the flap resected and case completed with the final sutures. (Modified after Revue de Chirurgie Plastique, No 4, January, 1934. Lower illustrations show flap turned 90 degrees only. Hair line must be resected under such circumstances, see text.)

will be for the border of the lid to lie horizontally during the healing period, for its own elasticity will not be able to come so much into play. *a*, *b*, *c*, represents the flap; *m*, *n*, *o*, represents the edges left after cutting the flap; *d*, *e*, *f*, represents the triangle cut to receive *a*, *b*, *c*: and *c*, *k*, *o*, *r*, represents the pedicle. The small portions of the wound marked *d-t* and *m-s* remain free for the period of healing, to be repaired later.

The Restoration of Lashes.—The last remaining lid margin deformity to be considered is that involving the loss of the lashes. There are several different methods available for its correction. The first and simplest is the use of a free skin graft, from the skin of the upper lid below the brow, into the lid margin. The lid margin is released and rolled outwardly with a mattress suture. The graft is then cut to size and sutured into position, a temporary tarsorrhaphy and a pressure bandage completing the operation. If these grafts can be cut from a part of the brow nearer to the nasal than to the temporal region, more hair follicles can be obtained in grafts of a narrower width as the hairs are thicker at the nasal end of the eyebrow. Grafts can be placed into the upper and lower lid margins, following upper and lower lid reconstructions, after a traumatic enucleation, and with extensive defects in both upper and lower lids, while the lid margins are still connected with a median tarsorrhaphy. Ectropion with the loss of the lashes can be corrected simultaneously by a large free skin graft from the brow or from the opposite lid. Full thickness grafts from the occipital scalp can be inserted into the lid margin of the lower lid following its reconstruction. The graft must be cut with the direction of the hair follicles placed so that they follow the line of the normal lashes in their growth. A further method is possible when an extensive ectropion of both lids has been corrected by the use of a large free skin Ollier-Thiersch graft and intermarginal adhesions. A few weeks before these adhesions are cut, free grafts from the brow are to be placed in a correcting position with a minimum number of sutures. After the intermarginal adhesions have been cut, the line of transplanted lashes should lie close to the margin of the lid. A fifth method of transplanting lashes presents itself though the author has never had occasion to use it. In very severe cases of ectropion of the upper lid following extensive burns, the lid margin may be so high that it can be incised, at such a level, so as to include a portion of the lower margin of the eyebrow in the new lid margin as its restored line of cilia. Wheeler first made this suggestion.

Obliquity of the Palpebral Fissure.—Much can be done in this condition through scar tissue resection and the conservation and replacement of every bit of soft tissue remaining. Some planning with a model and with oiled silk is perhaps advisable before the operation. Figures 229 to 233 illustrate a case reported by Gillies as an example to illustrate this point. The illustrations need little explanation. The flaps *A–A′* are supported by underlying subcutaneous flaps sutured to the periosteum of the rim of the orbit; also flap *B–C* was anchored to the periosteum at the level of the inner canthus. Thus flap *B–C* not only supports flaps *A–A′* at a normal level but also relieves it from tension through the purchase obtained by this periosteal suture. Roy also speaks of this periosteal suture at the canthus as a point of extreme value. This case was completed through the use of a homograft of cartilage into the socket to form a prosthesis stump there.

Wheeler calls attention to a method by which this defect is to be corrected. The scar tissue is resected to the periosteum, and the outer canthus incised for 2 to 3 cm. In this way a sliding flap is formed of the entire thickness of the lower lid and all the infra-orbital tissues. This flap is moved up toward the canthus into a slightly overcorrected position. In this procedure the incision line must follow the scar accurately so th...

FIG. 229.—Healed primary condition (Courtesy of Oxford Medical Publications.)

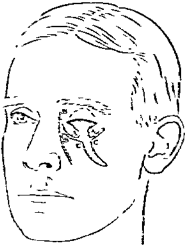


FIG. 230.—Excision of scar and outlining of flaps. (Courtesy of Oxford Medical Publications.)

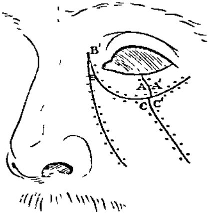


FIG. 231.—Suture. (Courtesy of Oxford Medical Publications.)

FIG. 232.—Immediately after plastic. (Courtesy of Oxford Medical Publications.)

FIG. 233.—Case completed. (Courtesy of Oxford Medical Publications.)

cheek incision obliques across the face in a series of steps or terraces. Small Burow's triangles may be resected at the end of the resection and of the incision passing out from the canthus. They will facilitate the movement

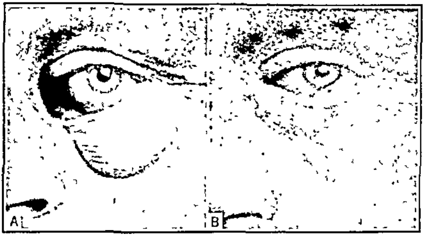


FIG. 234.—*A*, obliquity of palpebral fissure *B*, correction by scar resection, triangle resection and suture (This technique illustrates the common windshield cuts) (By permission of Axenfeld)

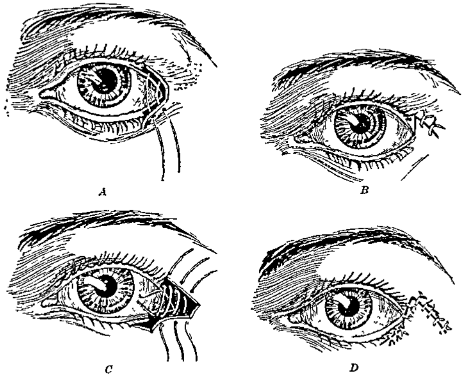


FIG 235.—*A* and *B*, classical Fuchs' tarsorrhaphy; *C* and *D*, the author's modification.

of the sliding flap without tension or puckering. The sutures placed into the skin of the flap are placed at a lower level than those placed into the skin of the fixed portion of the face so that when they are tied the flap is

moved upward and toward the canthus under correction. In the cul-de-sac remaining and now reformed, a series of sutures placed there holds the inner surface of this flap in a proper position and at the same time assists and augments the action of those upon the outer surface. The apex suture of this sliding flap should always be buried into the periosteum of the crista lacrimalis. This technique is quite satisfactory for correcting the level of the inner canthus. The valuable method of Esser explained under canthal repairs is also applicable to the correction of this condition.

Often it will be necessary to excise a triangle of tissue at the canthus to allow the apex of the sliding flap room for elevation and duction. This has been explained. Figure 235 illustrates the operation. Figure 234 illustrates beautifully a result obtained by Axenfeld with this procedure.

Relaxation or drooping of the canthus is corrected by any modification of an operation which takes the redundant tissue from one lid and by means of a pedicle flap elevates the level of the canthus. Invariably in such an operation it will be necessary that the operator undermine widely all tissues surrounding the defect, even including the conjunctiva lining the cul-de-sacs, so that when the level of the canthus is raised, the other tissues will rotate at the same time. The author's modification of Fuchs' tarsorrhaphy (Fig. 235) is an operation which oftentimes fulfills the demands of this deformity. Free skin grafts will be of little value in these conditions because usually there is such a large amount of scar tissue present. If this can be completely removed, the use of a free skin graft over a mold, after the method described by Esser, might give good results.

The same rules and methods apply for the correction of an elevated canthus as are present in the correction of a depressed canthus. The incision, flaps and sutures are simply inverted so that similar end results may be obtained.

SINUSES ABOUT THE CANTHI

Persistent lacrimal gland fistulæ may be a constant source of distress in cases with grave plastic defects. A wide resection of any soft tissue which could possibly harbor a single acinus of the badly dispersed lacrimal gland is necessary. The defect made thereby should be covered with a free skin graft. This point is mentioned because it may be of value in similar cases.

Fistulæ about the inner canthus, complicating and due to nasal accessory sinus disease, or following operation because of sinus disease, will not close as long as these originate in an infected sinus. The correction of an upper lid notch with ectropion, at the inner angle, from former frontal sinus pathology, sometimes following a sinusotomy, is by scar resection, median tarsorrhaphy, and a free skin graft. A complete failure may occur from the plastic surgery because the sinus was reopened by this plastic surgery. One is completely at the mercy of the rhinologist, in these cases; for if he states that the sinuses (nasal accessory) are clean and that plastic surgery can be started upon the lid, one has no other alternative but to believe him. Figure 236 is such a case. This was followed by a partial success and is awaiting further rhinological treatment at the time of this writing.

An injection of the course of these fistulæ with a dye, and their subsequent resection, might be successful, but usually this procedure will only result in a second larger fistula unless the case has had a radical sinusotomy or sinusectomy. When this is done, with a cure following, the fistula will heal

spontaneously. Recently, a fistula, opening into the naso-palpebral fold, which led back through infected ethmoidal cells into an infected sphenoidal sinus, recovered within seventy-two hours after radical sinusectomy, with the reëstablishment of lacrimal drainage which had been previously lost. This same spontaneous closure also applies to lacrimal sac fistulæ. The residual scar from these fistulæ is a small pit needing resection and a few very small sutures at the most for closure.

FIG 236 —Fistulæ about the canthi from the frontal sinuses *A*, before operation, *B*, after correction, *C*, same, with lids closed

RESTORATION OF THE CARUNCLE

Pigmented nevus of the caruncle is of importance first, because it is objectionable cosmetically, and second (and more important) it may become malignant. Applebaum[1] recently presented a very satisfactory technique for restorative surgery.

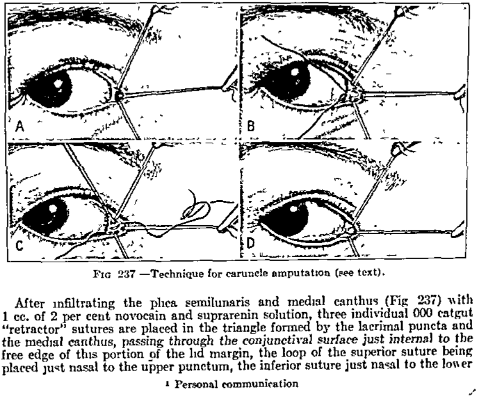


FIG 237 —Technique for caruncle amputation (see text).

After infiltrating the plica semilunaris and medial canthus (Fig 237) with 1 cc. of 2 per cent novocain and suprarenin solution, three individual 000 catgut "retractor" sutures are placed in the triangle formed by the lacrimal puncta and the medial canthus, *passing through the conjunctival surface just internal to the* free edge of this portion of the lid margin, the loop of the superior suture being placed just nasal to the upper punctum, the inferior suture just nasal to the lower

[1] Personal communication

punctum, and the middle suture at the medial canthal angle. The two ends of each of these sutures are then locked in individual hæmostats (Fig. 237, *A*). Traction applied upon these by the assistant gave a clear exposure of the caruncle. A No. 3 black silk suture is then passed through the base of the *pigmented caruncle* (Fig. 237, *B*). After placing a knot over the apex of the caruncle to prevent slipping, the two ends of this suture are also locked in a hæmostat. With the caruncle clearly exposed and drawn up by traction upon this black silk suture, a No. 1 black silk suture is passed around the base of the caruncle, 2 mm. below the line of pigment demarcation, like the string of a tobacco-pouch, halting after every two or three stitches to make a corresponding circumferential incision midway between this suture and the line of pigment demarcation (Fig. 237, *C*). As this suture is completed, the caruncle is amputated together with approximately 1 mm. of normal (non-pigmented) conjunctiva. As the suture is tied, the exposed caruncle bed is closed when the lips of the stump puckered (Fig. 237, *D*).

The inner surface of the stump is finally touched with a fine cotton applicator dipped in tincture of iodine and the retractor sutures removed. The technique is equally applicable for post-traumatic scarring and the subsequent resection of this.

TARSORRHAPHY

Temporary tarsorrhaphies are utilized for many different purposes and are of tremendous importance in the correction of certain lid deformities. In socket reconstruction, tarsorrhaphy sutures should be mattressed through the upper and lower lid and tied over tiny rubber plates perforated with two holes, through small pearl buttons or even over a very small roll of gauze. These latter, however, have a tendency to cause necrosis so they should not be used unless necessary. A permanent tarsorrhaphy is indicated as an adjunct in the correction of plastic defects and also as a prophylactic in certain corneal conditions. Keratitis e lagophthalmo, impending or already established, can be improved decidedly, and prevented by such a procedure (Fig. 238). The exophthalmos of toxic goiter can be made safe by intermarginal adhesions, though the Axenfeld sutures, to be discussed under exophthalmos, are a somewhat better procedure. The author has used it satisfactorily in a high degree of exophthalmos with a retrobulbar tuberculoma. (Wheeler's angle tarsorrhaphy is especially satisfactory for the high degrees of stationary exophthalmos.) This is also applicable in part to obliquity of the palpebral fissure. Intermarginal adhesions are necessary for the correction of cicatricial ectropion of the

FIG. 238.—Permanent median tarsorrhaphy for: *A*, ulcerative keratitis e lagophthalmo (left facial paralysis the cause of the corneal exposure); *B*, during recovery from free skin graft correction of ectropion of lower lid; and *C*, of upper lid.

factor in minimizing the appearance of a palpebral fissure which has been shortened in its length. Local anesthesia by the block method is usually sufficient, though it must be combined with instillations of cocain. An incision is first made in the intermarginal line of the lower lid, parallel to the lid margin and posterior to the lashes. A second vertical cut is then made, at right angles from this, at a distance from the external canthal angle equal to the amount of shortening of the palpebral fissure one desires.

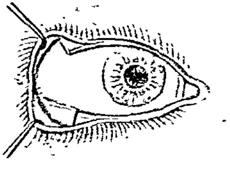


FIG. 240.—Tarsorrhaphy after Elschnig. Intermarginal incision in the upper and lower lid, beginning from the external canthus. (In the figure the intermarginal incision is made somewhat longer, in order to demonstrate more distinctly the incisions in the tarsus.) Vertical incision through the tarsus of the lower lid. A triangular piece is excised from the tarsus of the upper lid. (Courtesy of P. Blakiston's Son & Co.)

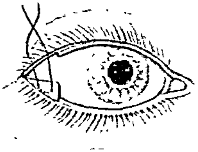


FIG. 241

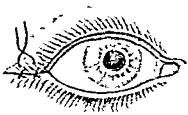


FIG. 242

FIG. 241.—Tarsorrhaphy after Elschnig. Suture applied in the tarsal flap of the lower lid. A short portion of the thread (dotted line) is situated on the conjunctival side. Both ends of the thread are carried from behind through the skin of the upper lid, several millimeters above the lid-margin. The excision of the tarsus of the upper lid is indicated by dotted lines. (Courtesy of P. Blakiston's Son & Co.)

FIG. 242.—Tarsorrhaphy after Elschnig. Appearance of the palpebral fissure after tying the fixation-suture. Two skin-sutures (Courtesy of P. Blakiston's Son & Co.)

This is made for 4 to 5 mm. and, as Elschnig says, is made in the posterior lid lamina from the lid margin (Figs. 240–242). A very narrow strip is resected from the upper edge of this lamina. At the same time the skin tissue immediately behind the cilia is also removed over the same length of lid margin. The cilia, however, are spared. The same incisions are made in the upper lid at the outer canthus. The posterior lamina, however, in the upper lid is removed in its entirety from the height of this vertical cut

gins. It will be necessary to resect a small triangle of skin in the lower lid, apex toward the opposite canthus to prevent puckering of the skin when the sutures are placed. One double-armed suture is placed through the denuded area from without inward, and tied in the cul-de-sac formed. This will allow accurate coaptation of the lid margins deep inside the canthus formed. As the flap outlined is lifted and sutured, the palpebral fissure is shortened and the ptosis of the canthus corrected. Before the flap is sutured, the operator should be sure that all bands of tissue causing the deformity of the canthus have been removed. If this is not done, a part or the whole of the effect of the operation may be lost. The last step to finish the operation is a complete temporary median tarsorrhaphy.

A case of marked elevation of the canthus can be corrected by the use of a graft wrapped over a mold of dental compound. It illustrates a condition in which all of the scar tissue must be resected. All of the author's cases of this defect, *i. e.*, elevation of the canthus, had as a complication either a loss of a portion of the bony orbit or a markedly contracted socket. In the former type, the bony repair was done last, while in the latter type, the socket reconstruction was completed before any work was attempted upon the canthus. It was found that marked deformities of the canthi in the presence of contracted sockets will occasionally need no other correction save that done at the time of the socket restoration. (See also under this subject the reference to an operation by Roy included in the discussion of lagophthalmos.)

Figure 234, *A* and *B*, is a case from Axenfeld showing obliquity of the palpebral fissure, and the correction achieved through simple scar tissue resection and suture. Richet's plasty described in the Principles of Plastic Surgery is also quite applicable. In the cicatricial displacements of the canthal angle it is absolutely essential that all scar be removed. Under the section of scar resections and suture, this is again mentioned. It is sufficient at this point to call attention to its relevancy. If the operator is satisfied that there has been a loss of soft tissue and this is responsible for the obliquity of the palpebral fissure, that soft tissue which is missing must be replaced. If it cannot be done with a flap, then a free skin graft is necessary.

Median Tarsorrhaphy.—Median tarsorrhaphy is an operation which furnishes permanent intermarginal adhesions; necessary for the support of tissues after plastic correction as in a free skin graft correction of ectropion; for the treatment of keratitis e lagophthalmo; in various forms of superficial ulcerative keratitis; in dangerous degrees of exophthalmos and lagophthalmos (as seventh nerve facial paralysis) and with spastic entropion. Two or three areas for the intermarginal adhesions are usually sufficient, regardless of the indications. The puncti should be spared as well as the canthal angles. Under local anesthesia, each lid margin is everted with suitable forceps and two parallel, short 2 to 3 mm. cuts made upon the margin, posterior to the line of lashes. These are connected at their extremities by other shorter incisions, about 1 mm. long, and the rectangle of skin outlined is removed. A cataract knife or a keratome are satisfactory for making these incisions. The contiguous areas denuded should approximate each other upon the opposite lid margin; two or three such rectangles are prepared upon each opposite lid margin. Mattress sutures are then passed from one lid to the other, the points of insertion

up to the limbus. If even greater effect is necessary, a vertical incision can be made along the limbus; the conjunctiva released from this to retract from the limbus, and this defect filled in with a conjunctival flap from above the limbus. This is to be considered especially in blepharospasm due to corneal conditions; in spastic entropion; and in some cases of cicatricial angle ankyloblepharon (blepharophimosis). The simple canthotomy is sufficient for acute inflammatory processes, suppurative or otherwise; as with a severe gonorrheal conjunctivitis.

Kuhnt did the usual canthotomy and then cut a small rhomboidal or finger-shaped pedicle flap from the skin below the margin of the lower lid at the outer canthus, passed this across the angle of the cut canthus, and buried it beneath the conjunctiva, there to spread, permanently, this angle, and at the same time to lengthen the palpebral fissure, also permanently. The results are very satisfactory, though the cosmetic defect is rather obvious. Blaskovics has presented one slightly more satisfactory from the standpoint of appearance, and equally efficient. He cuts a V-shaped incision, apex downward, into the skin of the lower lid just beyond the external canthus, but with its medial arm running into the angle. This is lifted as a free triangular flap. An ordinary canthotomy is then done, and as the palpebral fissure and the upper lid relax to the width of the triangle resection, this triangular flap is folded upon itself to lie in the triangular gap in the upper lid upon its posterior surface. A mattress suture, through its apex, anchors this into this position, the needles on the suture emerging upon the lid surface where the suture ends are tied. The defect, from which the flap was lifted, is then closed in a vertical line with 2 or 3 interrupted silk sutures. Chalot,[1] Prince,[2] and Richet[3] also suggested various forms of these last two canthoplasties. In general, those described in detail are adequate for all indications.

Congenital anomalies at the outer canthal angle, while not uncommon, do occur and are not especially easily corrected. Congenital absence of the external canthal ligament with a broadening of the outer canthus as a result, is the most difficult of all to correct, unless a certain rather rigid technique is carried out. The palpebral fissure must be elongated either to a normal size if the condition is bilateral, or to the size in the opposite uninvolved eye. Secondly, a canthal ligament must be formed to hold this in correction.

An incision is first made in the line of the palpebral fissure through the broadened external angle canthal fold of a required and necessary length. Horizontal-crescentic incisions are then made in the upper and the lower lids through the skin only, from the incised canthal angle as in *B* of Figure 243. Strips of orbicularis palpebrarum are then dissected free from the upper and lower lid, remaining attached, however, to the outer horn of the superior and inferior tarsal cartilage. These are carried to the extreme outer angle of the palpebral fissure incision, crossed upon themselves there, and sutured finally to the periosteum of the outer orbital margin. This must be exposed by dissection. They form in this manner an external canthal ligament. The conjunctivæ and skin are then closed by fine sutures on the lid margins and in the angle. There should be no deformity

[1] Trait. Elem. de Chir. et de Med., Paris, 3d ed., p. 711, 1900
[2] Am. Jour. Med. Sci., 1866
[3] Trait. d'Anat. Med. Chir., 1851.

whatsoever remaining after the operation, and the patient should have good functioning lids. Wheeler[1] was the first to recommend this method for the utilization of the orbicularis palpebral fibers. The technique as carried out by the author, and as just described, has been universally successful. *It is applicable to defects of one lid, or to both lids for simultaneous correction.*

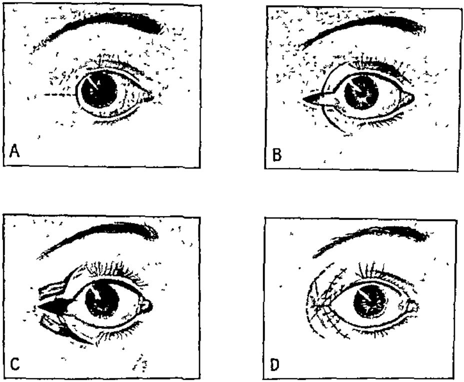


Fig 243 —Utilization of the orbicularis fibers for the correction of external canthal deformities, either congenital or cicatricial

COLOBOMATA

These conditions are both congenital and acquired. The former of the two can, with but few exceptions, be corrected by the use of Wheeler's *halving operation.*[2] *If the coloboma is so profound that this cannot be* done, then a procedure as discussed by Axenfeld,[3] and more recently by Wendell Hughes,[4] or the technique of Wicherkiewicz is necessary. The last two of these will be included under lid reconstructions.

Congenital Coloboma.—The correction of a congenital coloboma depends wholly upon obtaining a *closure of the tarsal and skin wounds* so that their suture lines do not lie in the same position. As Wheeler states, "Thus what is known in carpentry as halving, is accomplished, a union is assured even if there is a little sloughing of the skin. Furthermore, recurrence of the notch formation is prevented."

[1] Am. Jour. Surg , 42, 79 October, 1938.
[2] Trans. Inter. Cong Ophth , p. 367, 1922.
[3] *Augenheilkunde Verlag von Johann Ambrosius* Barth, in Leipzig, pp. 488–489, 1922.
[4] Trans. Am Acad Ophth. and Otolaryng , 1936,

Figure 244 was a unilateral broad V-shaped congenital coloboma, and Figure 245 a unilateral broad coloboma accompanied by large bilateral conjunctival xanthomata. (In this last case the tumor mass had to be resected first and conjunctival plastics done, with the conjunctiva from the

FIG 244 —Congenital coloboma *A*, before correction, *B*, sutures have just been removed; *C*, six months later, lids open

superior fornix to replace the conjunctiva of the inner angle and with mucous membrane grafts from the buccal mucosa to replace the inferior cul-de-sac.) Both were corrected according to the technique about to be outlined. Figure 244 shows the case at the time of her final discharge. The details of the technique are shown in Figure 246.

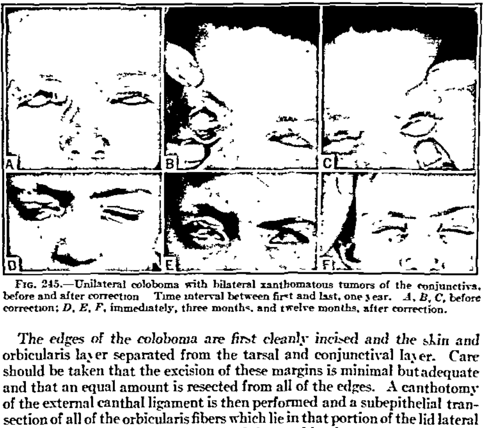


FIG. 245.—Unilateral coloboma with bilateral xanthomatous tumors of the conjunctiva, before and after correction Time interval between first and last, one year. *A*, *B*, *C*, before correction; *D*, *E*, *F*, immediately, three months, and twelve months, after correction.

The edges of the coloboma are first cleanly incised and the skin and orbicularis layer separated from the tarsal and conjunctival layer. Care should be taken that the excision of these margins is minimal but adequate and that an equal amount is resected from all of the edges. A canthotomy of the external canthal ligament is then performed and a subepithelial transection of all of the orbicularis fibers which lie in that portion of the lid lateral to the coloboma. The canthotomy and the myokinesis are necessary so that there will be adequate mobility to this lateral portion of the lid. The tarsal

conjunctival gap is then closed with buried No. 6-0 catgut sutures. These pass into the tarsus, but they should not go through the conjunctiva onto

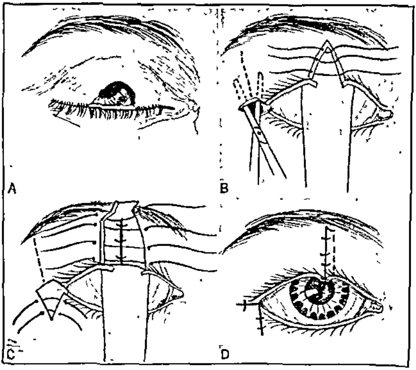


Fig. 246.—A, B, C, and D, the technique of Wheeler's halving operation emphasizing the importance of the section of the orbicularis fibers the closure at the margin, and the skin flap necessary to offset the line of skin sutures from the tarsal catgut sutures

the posterior surface of the lid Three to four are necessary for satisfactory closure. They are cut short. The formation of the skin flap is then necessary. As stated, in the repair of through-and-through lacerations of the lid, conjunctiva and skin sutures must not overlie each other. Hence, it is necessary to arrange a tiny flap of skin from the upper lid so that this will be prevented. A small rectangular area of the tarsus is exposed on the lateral lip of the coloboma by the clean resection of skin there. At the same time a small tongue of skin is dissected from the medial lip of the coloboma, as in Figure 247, which is an enlargement from a moving picture film of this operation and illustrates the formation of this tongue of skin, though in this picture the rectangular area for the reception of this tongue has not as yet been removed. It illustrates well, however, the size necessary for the correction. Black silk sutures are used to suture this in position.

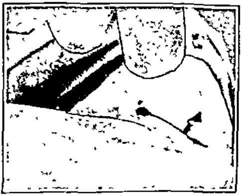


Fig. 247.—Enlargement of moving picture film of the halving operation, showing the formation of the skin flap for closing the skin surface

The suturing should start above, and after the first two have been placed, two tiny tongues or flaps should be cut free from the lid margin, above the level of the hair line, as previously described under lid margin deformities. The remaining sutures are now placed and tied. It may be necessary to place a last suture along the lid margin through the tongues formed there to obtain satisfactory coaptation of these tongues and also to assure accurate approximation at the lid margin in the skin suture line. Before the

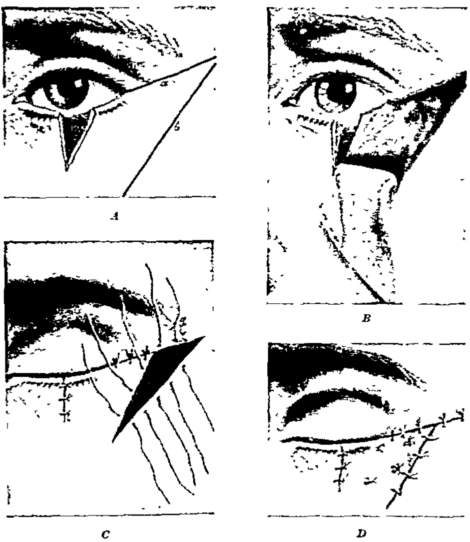


FIG. 248.—Correction of lid coloboma.[1]

canthotomy is closed, it will be necessary to resect a small triangle of skin, apex downward (von Ammon's triangle resection for ectropion) at the outer angle of the lower lid, to overcome some puckering which occurs there as a result of the myokinesis in the upper lid and the actual shortening in the upper lid and in the palpebral fissure which has resulted from the surgery, otherwise the lower lid will be the longer. Figure 246, C, shows

[1] From Handbuch der ärztlichen Erfahrungen im Weltkriege, Band 5, Augenheilkunde von Prof. Dr. Axenfeld, Verlag Johann Ambrosius Barth, Leipzig, 1922.

the sutures for this, and the triangle resection. Wheeler passes a double-armed mattress suture through the flaps, tying it over a small rubber plate. The author has used this in several instances where there seemed to be some tension present. The operation is completed with a moist, cotton film dressing and a slight pressure bandage. The first dressing is done on the third day. It is advisable to remove this mattress suture and the rubber plate upon the third day. The other sutures may be removed after the sixth day, depending upon the postoperative recovery.

Falchi[1] corrected congenital coloboma of the upper lid in a slightly different manner. The first part of his resection was similar to that above, that is, a triangular incision of the edges of the defect. He made no attempt, however, to separate the lid into its two layers. Instead he cut a second incision upward into the lid, just within the external canthus, curving slightly temporalwards, through the entire width and thickness of the lid, thus mobilizing a free tongue. The coloboma defect is closed with this tongue by sutures, and an intermarginal median tarsorrhaphy performed. The outer third of the lid margin, with its triangular defect resulting from the movement of the tongue first formed, is closed on its conjunctival surface by the undermining of the conjunctiva and necessary sutures, and on the skin surface by a triangular or rectangular flap moved over from the skin of the face immediately lateral to the external angle, the site from which this was cut being, in turn, closed with sutures after undermining the edges. The intermarginal adhesions arranged for the permanent tarsorrhaphy should include the lid margin of this last flap as well The intermarginal adhesions should not be removed within six weeks. The technique is not as satisfactory as Wheeler's for the usual case of congenital coloboma, but it must be utilized in the greater defects.

Axenfeld has modified Falchi's technique for coloboma of the lower lid, both cicatricial as well as congenital, very satisfactorily. The second V-shaped incision made, at the external canthus, preparatory to closing the coloboma is not made by him through the full thickness of the lid but through the skin alone, rather similar to Dieffenbach's plastic. He then removes a triangular cartilage and skin section from the posterior surface of the lobe of the ear, of a size and shape to match the colobomata defect exactly. This graft is sutured upon the posterior surface of the flap so that as the flap is swung into place, bridging the V of the coloboma, the cartilage and skin graft will form a posterior surface of the lid. Figure 248, *A*, *B*, *C* and *D*, illustrates the technique. This same principle of ear cartilage and skin graft can be utilized in many similar instances. If the eyeball is normally *in situ*, it dare not be used upon the upper lid; a tarsus-conjunctival inlay may replace it. It can, however, be used in the lower lid (even if the eyeball is not present) as long as the epithelium does not come in contact with the cornea.

In the correction of these colobomata the first essential necessary is the closure of the tarsal conjunctival layer. The subsequent skin defect is not so difficult a problem. Some of these subsequent defects may be so simple that it is possible to swing a small, spatula-shaped, thin pedicle flap into the defect from the temporal portion of the tissues immediately external to the outer canthus below and at the outer termination of the eyebrow. If care is taken in this dissection, a line of hairs may be included

[1] Arch. f. Augenh., Band 59, Heft 3, 1908.

in the flap to replace those absent at the marginal part of the coloboma after it has been corrected. The pedicle of this flap should not be tubulated but sutured into an incision made from its base to the defect in the lid, or the pedicle made without an epidermic covering and buried under the skin of the lid according to the technique of Esser. A second method is to cover the defect with a free skin graft from the upper lid of the opposite eye. In this graft a line of hair follicles also can be transplanted at the same time to replace those absent at the base of the defect. The third method possible is one suggested by Wicherkiewicz, and one which, while not new, was most satisfactory when used by the author. After the conjunctival and tarsal repair is completed, a triangular flap is outlined on the

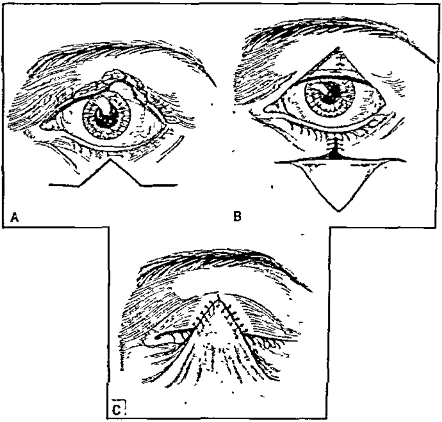


FIG 249 —Wicherkiewicz technique. (Courtesy of P Blakiston's Son & Co)

opposite lid with its apex upward and its thick base well attached in its original position without later torsion (Fig. 249, *A*, *B* and *C*). This flap must be large enough to cover the entire defect. The apex is thinned out somewhat and then allowed to fall back. The skin defect beneath the flap is closed after two lateral incisions have been made continuous with the base of the flap Sufficient undermining of the skin of the lid is done, so that the triangular defect beneath the flap can be closed with a line of sutures without compressing or twisting the base of the flap. The epithelial edges of the coloboma are then to be freshened, and this triangular flap moved up into the coloboma and carefully sutured there with silk. The flap should be left in place for ten days when the dressing and sutures may

be removed and the pedicle of the flap resected. The area at which the pedicle was attached will need a slight amount of undermining before it is closed with black silk or with an intradermic suture.

The original operation transplanted the entire thickness of the lower lid into a coloboma of the upper lid. The defect, which results later, in the lower lid, must then in turn be corrected by surgery. This is no more simple a procedure than that for the defect which existed in the upper lid; hence, the full lid thickness transplant is not recommended by the author.

Traumatic Colobomata.—Recent traumatic colobomata, especially of the lower lid, can be corrected by débridement with removal of the scar and the incision line, and with a subsequent suturing of the operative wound, the medial lip of the wound remaining fixed while the outer lip is moved upward and inward by the sutures. In each instance each suture, as it is placed in the lateral lip, is at a slightly lower level than is its other end in the fixed medial lip. In this, care should be taken that there are no marginal notchings.

Sharply angulated cicatricial defects of the lower lid often can be corrected by excision of the entire area with a V-shaped incision at the end of the excision line, apex downward with its wings lying upon each side of the excision line. This will allow sufficient relaxation, so that when the sutures are placed in to form a Y, the lid margin will be without indentation The Y incision allows the tissue within the incisions to move upward so that the lid margin is made level throughout its course. The defect then present at the end of the incision will be triangular, apex downward. The sutures to close this defect are to be placed from side to side, but never to be placed in the flap, which has been moved upward. The uppermost at the place where the vertical stroke meets the more horizontal strokes can be anchored to the subcutaneous tissues rather than to the skin. (The arms of this Y will drop slightly in most instances.) Axenfeld also calls attention to the correction of such defects in this manner, especially when the defect is extensive and near the canthus. He also incises with one wing of his V-shaped incision as a continuation of the excision line, the other pointing toward the opposite canthus. This is augmented by a second incision angulating from the opposite canthus outward. This allows an easy correction of the defect. The incision at the canthus sutures into a straight line, while the other takes the shape of a capital L. This method will also correct some cases of moderate obliquity of the lower lid margin. Emphasis must be laid upon the careful and complete excision of all scar tissue.

Axenfeld also corrects small indentations or incisuræ in the lid margins in another ingenious manner. By excision of tissue including the cartilage of the lid, the indentations are changed to rectangular defects. These are filled in by a squared sliding flap from the skin of the lid and the conjunctiva below the defect. This sliding flap is formed by a continuation of the two parallel vertical incisions which outlined the rectangular defect. The flap is moved upward to the lid margin and there sutured into position firmly to the edges of the margin. When the defects are nearer the canthal angles than the center, he uses, of necessity, a slightly different technique. He first resects the deformity or the defect and inserts into the notch a free graft of ear cartilage cut to the exact size and shape of the defect and the resected tarsus. This is then covered by horizontal epidermal and conjunctival

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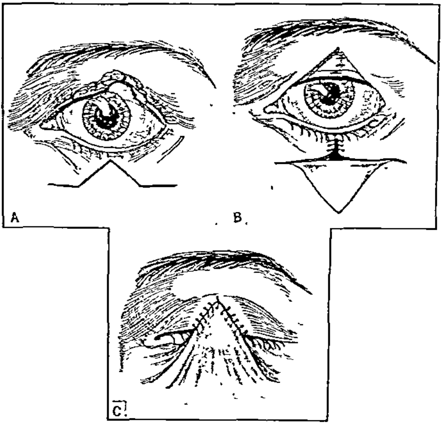

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pedicle flaps cut with their pedicles at the canthal angles and brought up over the cartilage graft to a level with the remainder of the lid margin. (See Fig. 251.) The elevation of these small flaps is made easy by the different levels in which the sutures are to be inserted into the lid margin and into the flaps. When the defect is one of more extensive tissue loss without much scar replacement and at the outer angle, his modification of the Kuhnt blepharoplasty is valuable. A right-angle cut is made from the lid margin in length equal to the vertical width of the defect, and at the end of this at a distance equal to or slightly more than the depth of the defect from the proper level of the lid margin. A second horizontal incision is made. The flap thus outlined is undercut and moved upward until its free edge reaches the normal level of the lid margin without tension. It is *anchored there by its two corners to the lid margins remaining.* The raw surface then presenting is covered with a vertical flap from the cheek, its pedicle at the outer canthal angle; this is swung up and sutured into the irregularly quadrilateral defect formed (Fig. 250).

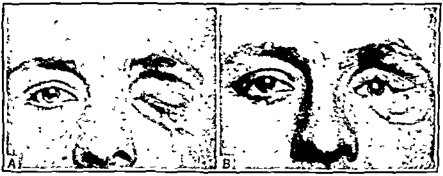


FIG 250.—Correction of traumatic coloboma, Kuhnt technique (By permission of Dr. Axenfeld.)

The repair of a deformed canthus, with a coloboma, necessitates an operation with some type of pedicle flap. Occasionally by the wide undermining of the tissues at the canthus it may not be necessary, but this exception is very rare. The simplest operation to use is one suggested by Blaskovics. All the others recommended are modifications of this type of operation. The lid margins at the canthus are incised and released until they will move freely without tension. A triangular-shaped pedicle flap is then moved over and sutured into place, to fill the defect formed by the dissection. If the outer canthus demands repair, the flap should be taken from the temporal junction of the upper lid; for the inner canthus, from the nasal junction of the lower lid. When a flap, as described, is used there is danger that an uncovered raw area will remain beneath the flap of the epithelium in the canthal angle. As healing takes place this will contract and invert the lids into an entropion or at the best into a trichiasis at the canthus. To obviate this occasional unfortunate development it was suggested (Hasner's canthoplasty) that the pedicle flap have its apex divided into a two-lobed bootjack-shape, one lobe to be placed into the upper lid and the second into the lower lid, the angle between the two lobes to coincide with the position of the canthus. A similar difficulty, however, is present here if one is particular that both palpebral fissures will be of the

same length. If, with this last type of operation, the conjunctiva is released at the lid margin for a distance of 3 to 4 mm. from both the upper and lower lids, and the lid margins temporarily sutured together in the line of the palpebral fissure with a running suture of fine dermol before the flap is moved into position, this complication will not develop

The author in some instances has had rather good results with *free skin grafts* for the covering of canthal defects, but this procedure is not strongly recommended. In many cases of canthal repair the operator will find himself well into the field of a tarsorrhaphy, in that most of these cases need, *in addition to the reconstruction* of the canthus, a readjustment of the length of the palpebral fissure

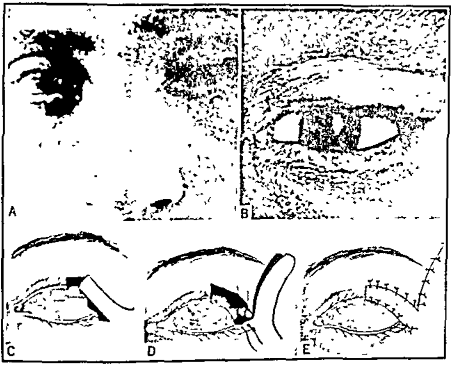


FIG. 251.—Postoperative coloboma at external angle. *A* before surgery, *B*, after surgery, *C*, *D* and *E*, technique of correction

In downward displacements of the inner canthus, Esser cuts a free triangular flap from the upper lid with the base toward the nose. He turns the flap down into a denuded surface of the lower lid formed there by the release of the scar contraction. As a means of preventing further contraction, the lid margin is held up for a time by a row of looped sutures *from the lid, across the upper lid into the eyebrow*. This same technique, though revised, will answer for the outer canthus, and still more revised will correct an upward displacement of either canthus. The latter deformity is much less common.

Figure 251, *A*, illustrates a not uncommon coloboma of the upper lid at the outer (or inner) canthal angle, following reconstruction of the lids after an orbital exenteration; *B* shows the same lid completed with an ocular prosthesis in the socket; and *C*, *D*, and *E*, the technique necessary

for this surgery. The original defect is first converted into a quadrilateral defect; a small finger pedicle flap is then raised from the skin of the upper lid immediately at the edge of this defect, the flap turned upon itself and sutured into place, epithelial surface posterior, so that now there is a satisfactory epithelialized posterior surface of the upper lid. The ocular prosthesis should be in position during this surgery. The raw surface of this flap and the defect from which it was removed is in turn covered by a second flap, this being lifted from the skin line of the defect, but more temporally. This is turned down, as in *E* of Figure 251, and sutured into place. After both flaps have healed, the thickened twisted pedicle of flap No 1 may be resected, the buried epithelial surface also removed, and this last operative wound closed with sutures. A similar technique is satisfactory for marginal and angle traumatic colobomata of the upper or lower lid, as in Figure 252, *A*, but the technique will not be proper if the eyeball is present, for the epithelial surface will come in contact with the cornea following recovery. In the case illustrated the patient is wearing

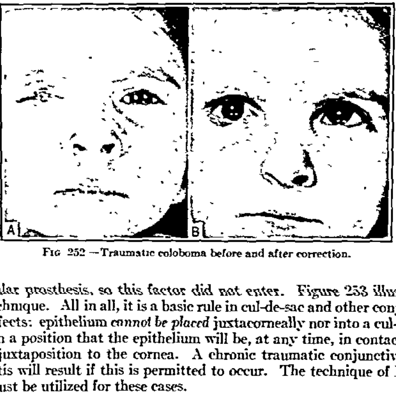


Fig 252 —Traumatic coloboma before and after correction.

an ocular prosthesis, so this factor did not enter. Figure 253 illustrates the technique. All in all, it is a basic rule in cul-de-sac and other conjunctival defects: epithelium *cannot be placed* juxtacorneally nor into a cul-de-sac in such a position that the epithelium will be, at any time, in contact with or in juxtaposition to the cornea. A chronic traumatic conjunctivitis or keratitis will result if this is permitted to occur. The technique of Figure 211 must be utilized for these cases.

This shows the formation of a mucous membrane lined pocket to be made below in the skin of the face and the lower lid. An incision is made in length equal to the width of the coloboma plus that tissue which will be further resected from the upper lid on the lateral lip of the coloboma in the final correcting operation. The depth of the pocket must be equal to the greatest vertical width of the coloboma, *i. e.*, the distance from the lid margin to the upper point of the coloboma. A mucous membrane graft is cut from the buccal mucosa, thinned out properly and wrapped over a very thin plate of dental paraffin or dental stent. This is placed on the paraffin,

the mucous membrane surface internally, the raw surface externally, and the paraffin plate or plaque with its surrounding graft buried into this pocket formed under the skin at that place, the line of incision closed with sutures, and the site dressed with a pressure bandage. Eight days later the dressing can be removed, the sutures taken out, the paraffin plaque removed, the redundant graft which is now necrotic resected, the pocket

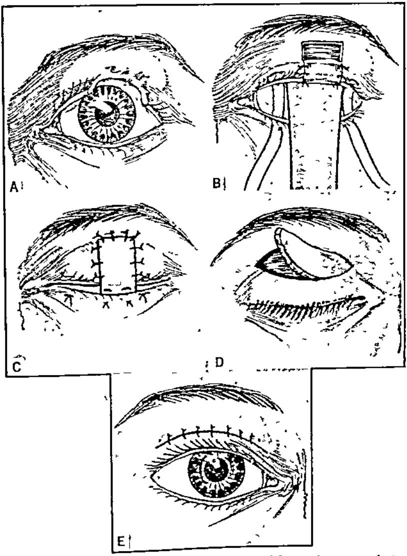


FIG. 253 —Technique for the correction of traumatic coloboma after an enucleation (glass eye is sketched in as present in the socket). *A*, original defect; *B*, hinged flap; *C*, graft covering of this as removed in *D*; *E*, closure of defect in opposite lid.

washed out with saline, and a second paraffin plaque of the same size is reintroduced for two to four additional days. At this time then, the edges of the coloboma are resected as well as all the skin of the upper lid which lies laterally from the coloboma. All cicatrix must be removed. A pedicle flap is now raised, its correcting head comprising the epithelial external surface and the mucous membrane lined posterior surface of the outer

of this pocket formed. This is raised into the upper lid, as in *C* of Figure 211, and sutured into position. The mucous membrane surface will now form a mucous membrane surface for the upper lid, and the epithelial surface of the flap will complete the external surface of the lid. Attention must be paid to the accurate approximation of mucous membrane to conjunctiva, and of skin to skin; especially important is this at the new formed canthal angle. When the mucous membrane pocket is first made, accurate measurements should be taken to be certain that the pocket is so placed that it can be moved up into the coloboma, subsequently, without either too much tension upon the pedicle flap (too short) or without an undue

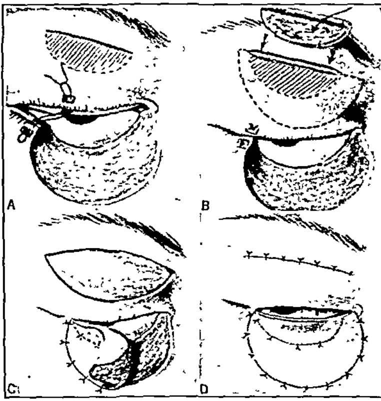


FIG. 254 —Plastic repair of a post-malignancy coloboma; *A* and *B*, the defect and implant of mucous membrane; *C* and *D*, completion of the surgery. (Hughes, personal communication.)

relaxation of the pedicle flap (too long). A layer of mucous membrane remains upon the face in the skin below the lid. This must be removed by sharp dissection, because otherwise it would be quite conspicuous, and the skin closed by approximation sutures at the same time that the incision from which the pedicle flap is lifted is also closed. Any skin cut from the upper lid may be utilized to fill in this defect, rather than discarding it.

Wendell L. Hughes[1] utilized the same principle in a most clever manner. His case was a coloboma of the lid resulting from a tumor mass. At the time the tumor was removed, by diathermy, he arranged intermar-
median adhesions of that portion of the lid still present and l

[1] Arch. Ophth., 10, 198, August, 1933.

mucous membrane graft into the upper lid below the eyebrow (Fig. 254). His *intermarginal adhesion* covered all but the very lower part of the cornea for its temporary protection, and he wrapped his mucous membrane graft over a small metal form (Fig. 254, *B* and *C*) instead of the paraffin plaque already mentioned. (The paraffin plaque molds itself by the pressure bandage and as the result of the normal warmth of the body, and it seems is to be preferred.) He covered this with a perforated piece of cellulose acetate to which a small amount of sterile petrolatum was applied, this placed *directly over the lid and the denuded surface inferiorly*. A pressure dressing of gauze fluffs was kept in place for one week. At the first dressing the rubber plates used for the intermarginal adhesions were removed and a light dressing changed at three day intervals was retained until the third week after the operation. The remaining stages of his operation illustrated in *C* and *D* were then carried out. At this time the area of granulation in the denuded portion below had shrunk somewhat *This granulation was removed to receive the graft from the upper lid.* The skin of the upper lid including that part lined by mucous membrane was then removed. The mucous membrane edge was sewn to the conjunctiva and the edges of the skin were approximated by fine interrupted black silk sutures. A dressing of perforated silk, moistened with petrolatum, was applied directly over the eyelids and the grafts, gauze fluffs above this, and pressure applied with adhesive tape and a tight bandage. The first dressing was changed after one week, a similar one being applied for another five days. After that a light dressing was used which was changed daily for three weeks after this last operation. The intermarginal adhesions were kept intact for six weeks and upon cutting these the lid assumed the relatively normal position as shown in Figure 254, *D*. The technique is ideal, and the results obtained through its use should be splendid. "Far better than any which could be achieved," as Wheeler stated, "through any form of irradiation."

EPICANTHUS

Congenital Epicanthus.—True epicanthus is a congenital condition and *not especially common in the white races*, at least to such a degree that an operation is necessary. The old and simplest way of correcting it was by the resection of a spindle-shaped area of skin above the bridge of the nose. As this area is sutured together, the epicanthal folds should smooth out with a complete correction resulting. This operation unfortunately leaves a scar more or less conspicuous. The operation advised by Blaskovics for unilateral epicanthus is quite applicable to bilateral epicanthus as well. The operation consists in the resection of a semilunar-shaped flap of skin, in the canthal fold, nearer the side of the nose than the canthus, followed by the closure of the defect with black silk sutures. The author has had very good results in both unilateral and bilateral epicanthus of *slight degree by the resection of an area of tissue in the canthal fold* somewhat different from this, one which removes the maximum amount of redundant skin from that position where this is most desired. The inner incision is made almost straight, the degree of the curvature of the outer incision depending upon the size of the canthal fold. The scar resulting from this operation follows the lines of the lid and is well up on the side of the bridge of the nose where it can be easily hidden, if necessary, with a spectacle

frame. The operation does not interfere with the normal level of the caruncle, nor will it cause distortion of the lacrimal punctum of either the upper or the lower lid.

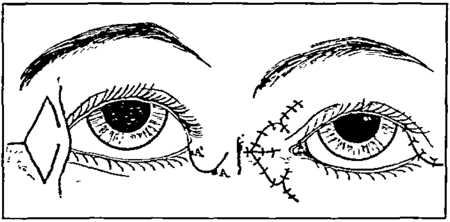


FIG. 255.—Blair's epicanthus operation.

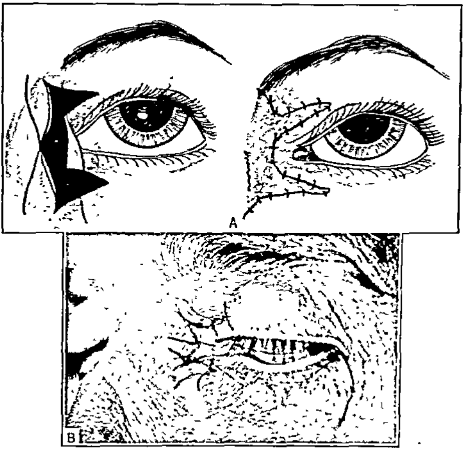


FIG. 256.—*A*, the author's modification placing the skin flaps into the upper and lower lids away from the canthal angle; *B*, the flaps as they lie on a cadaver.

Epicanthus of any degree is accompanied, however, by a very definite decrease in the length of the palpebral fissure. The resection of a semi-

lunar area in the canthal fold will smooth out an epicanthus, but it does not correct the shortened palpebral fissure. Many of these cases are also accompanied by ptosis.

The author's epicanthus operation, inspired by Blair's original technique (Fig. 255) for the correction of epicanthus has long been satisfactory. It utilizes the anterior fold of the epicanthus as two triangular flaps, these to be moved, respectively, the upper of the two into the upper lid, and the lower of the two into the lower lid. As a result, the tautness of the lids in epicanthus is removed; the fold is smoothed out, and there is no tight cicatrix remaining to cause eversion of the puncti. In Figure 256, *A* and *B*, this technique as used for the epicanthus is illustrated. Figure 257 is a case of congenital epicanthus before and after correction. (The black stain about the lids, in *B*, is mercurochrome, unfortunately applied just before this photograph was taken.) Figure 256 shows the formation of the two finger flaps with their pedicles above and below. A crescentic incision is first made parallel to the epicanthal fold and slightly medial to its fold. A second incision is made more medially to this, the central part of this second incision touching the central part of the first of the two. In this way a curving cross or X is made on the anterior surface of the canthal fold, the diverging arms above and below outlining the flaps Additional incisions are made into the upper and into the lower lid across the edge of the epicanthal fold for a distance equal to the length of the triangular flaps outlined by the first two incisions. These flaps are elevated by sharp dissection and the skin of the upper and the lower lids undermined, so that the flaps can be moved into the upper and the lower lid to lie smoothly therein. They are sutured into place with fine silk. Other sutures as necessary are used to close the roughly quadrilateral defect formed by their elevation and as a result of their transplantation.

Figures 258, 259 and 260 are two sisters and a brother with congenital epicanthus and with congenital palpebral clefts or incisuræ, in the case of Figure 258 almost to a complete uncovering of the lacrimal-nasal duct, as a coloboma. Each of these was corrected by means of a modification of the author's epicanthus operation. In each the first operation was limited to a lower part of the fold and to the lower lid The flaps as outlined in *B*, of Figure 258, were elevated by the horizontal incision parallel to the lid margin made into the lower lid, and a second one parallel to the first made above it along the lid margin after the removal of the cilia there. These were lifted by sharp dissection and folded away from their source. A V-shaped raw surface was thus uncovered. This was closed, after a canthotomy of the external canthal angle, with No. 6-0 plain catgut sutures, placed as shown. As the other wounds were closed the depressed canthal angle was elevated and the level of the lower lid straightened. The skin surface was then closed by a transplantation of the two flaps formed; the smaller of the two from the lid itself being drawn upward and inward across the new canthal angle, and the larger more vertical flap was transplanted downward and outward into the lower lid. This bridged the canthal angle and supported it. The case of Figure 259 needed some additional correction and this was done with V–Y incisions and sutures as shown. The additional surgery necessary for Figure 260 was the Blaskovics modification of the Siklösy incision, after a second flap was

done similar to the very first operation. The suture line is also shown in this from the secondary flap, as well as the end result (Figs. 260–262).

Fig. 257.—Congenital epicanthus. *A*, the original defect, *B*, the correction eight days later. (The dark stain is mercurochrome.)

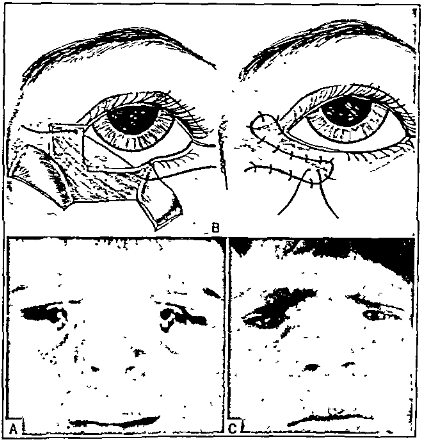


Fig. 258.—*A*, the original defect; *B*, the initial surgery for all cases; *C*, six months later. Catgut suture is shown in the left of *B*, above.

Traumatic Epicanthus.—Traumatic epicanthus is not always readily corrected. Scar tissue resection must be done first to remove all of the adherent scar. The ectropion which so often accompanies it is corrected at the same time. After this has healed satisfactorily, the angle is incised

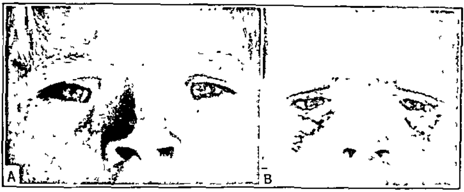


FIG. 259.—The initial defect in *A*, *B*. Y-Y suture line.

cleanly as for ankyloblepharon and the conjunctival and epithelial surfaces carefully sutured together edge to edge; the last and most important suture of all being placed directly into the angle. The caruncle should come forward to a normal position following this.

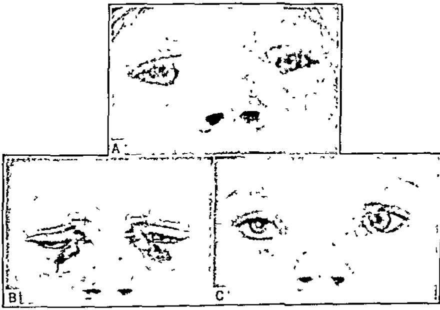


FIG. 260.—*A*, the initial defect; *B*, the suture line, the secondary flap shown in Figure 261; *C*, the final result.

Traumatic epicanthus, with a deformity of either the upper or the lower lid, can also be corrected by a crescent resection, with the resection of two tiny triangles, in addition, and the closure of the incisions in an S manner. The epicanthal fold is removed, and at the same time, a depressed internal angle can be elevated as much as is necessary, by simply increasing the

width of the base of the triangles, and offsetting the points of entrance of the needles in the two lips of the wound. If the deformity accompanying is largely in the upper lid, a second method is equally satisfactory, *i. e.*, a reversal of the flap in *B*, of Figure 261. Repeatedly each of these procedures has been the means of nicely completing cases which otherwise would have been far from satisfactory.

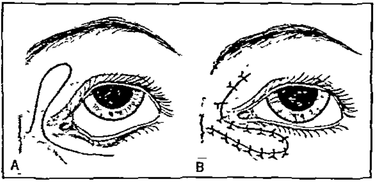


Fig 261 —The secondary flap

Epicanthus often develops after rhinoplastic work. In these cases after complete healing, the bridge of the nose is unnecessarily wide and the level of the bridge below the normal for the height of the superciliary ridges of the patient. The postoperative canthal folds are also too well marked. The transplanted skin over the bridge of the nose is thick and firm because it usually has been transplanted from the skin of the forehead. This lends itself very well to the operation proposed. A thick, spindle-shaped flap, attached at its upper pole, is lifted from this region, the entire

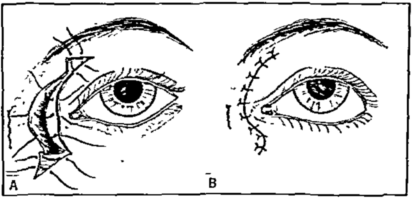


Fig 262 —The last incision line and suture for case illustrated in Figure 260

thickness of the skin being included in the graft. This is denuded of its superficial layers of epithelium by careful scraping with a sharp razor or razor blade. The flap is then buried at its original position, but now under the skin edges which have been brought together immediately above it. Not only is the epicanthus well corrected but the thickness of this flap elevates the level of the bridge of the nose an appreciable amount. Of course, there is a faintly discernible central scar on the bridge of the nose.

In the correction of windshield cuts at the inner canthus, further methods will be considered though they are largely a matter of scar resection and of subsequent sutures.

LAGOPHTHALMOS, EXOPHTHALMOS, ENOPHTHALMOS

The first of these conditions is quite the opposite from ptosis. In the latter of these two, the levator palpebræ superioris being paralyzed, the orbicularis fibers draw the lid into a downward malposition. In the former of the two, the fibers of the orbicularis oculi are paralyzed and the levator elevates the lid, preventing closure of the palpebral fissure. The various procedures available and to be utilized are also applicable to many cases of stationary exophthalmos, in that non-closure of the lid with keratitis e lagophthalmo is as imminent in exophthalmos as in lagophthalmos.

Lagophthalmos.—This condition is due to so many conditions and complicates so many defects that its discussion will take the operator into any one of several subsections as they are classed herein.

Lagophthalmos due to an acute paralysis of the seventh cranial nerve, and one in which the prognosis is good, can be corrected by a temporary tarsorrhaphy. Even a dressing of adhesive straps will protect temporarily an endangered cornea. With the incurable forms of facial paralysis the method of attack must be different. Even the best of results obtained following an anastomosis of the facial nerve to the hypoglossal nerve often fails to correct a distressing and dangerous lagophthalmos. Fuchs' tarsorrhaphy in these cases will occasionally improve the condition a sufficient amount. The relaxation ectropion of the lower lid accompanying it, if present to a degree demanding correction, can be corrected by a wedge resection ectropion operation. An adherent marginal tarsorrhaphy can be done similar to the intermarginal adhesions formed by Wheeler in his Ollier-Thiersch graft correction of ectropion. Two adhesions will be sufficient, one 4 mm. from the inner canthus and the other 5 mm. from the outer canthus. Two short incisions are made in the opposite lid margins and a small bit of marginal tissue removed. These raw surfaces are then sutured one to the other with silk mattress sutures tied over small rubber plates. These adhesions may be allowed to remain indefinitely The author has had 3 cases in which they have been present for from two to four years, though they are, however, somewhat conspicuous.

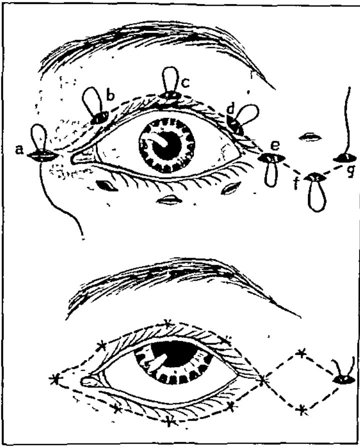
Wheeler's and Elschnig's tarsorrhaphies, see pp. 315–316, can be utilized for the least severe of these cases. Axenfeld has a very satisfactory suture which acts in the nature of an artificial orbicularis.[1] Figure 263, *A* and *B*, is a case of lagophthalmos before and after the implantation of this suture. It is a high degree unilateral exophthalmos with very early corneal involvement. The second photograph was taken shortly after the implantation of the suture. It has been universally successful for the author in each case wherein it was used, with the exception of one case of malignant exophthalmos following thyroid operation where, in spite of every surgical procedure done, the cornea sloughed and the eyeball was lost. A No. 1 white braided silk suture is carefully sterilized by boiling and then impregnated with sterile bone wax. A No. 6, half-curved eye needle is threaded

[1] Axenfeld: Augenheilkunde, *Handbuch der arztlichen Erfahrungen im Weltkriege*, 5, 497, 1914–1918, Johann A. Barth, Leipzig, 1922.

at one end, and at the other end a three-quarter, curved, short, stout needle, not larger than a No. 4, is threaded. The eyelids are carefully scrubbed with soap and water, painted with tincture of iodine or with a 3

FIG 263 —*A* and *B*, exophthalmos before and immediately after the Axenfeld suture.

A



B

FIG 264.—*A* and *B*, technique of Axenfeld's lagophthalmos suture.

per cent aqueous solution of picric acid. The following incisions are then made: Figure 264, *A* and *B*. A short incision over the internal canthal ligament parallel to the line of the ligament fibers and for a length of 4 mm.; three similar incision lines are made in the upper and the lower lids, one in the central portion of the lids and the other two equidistant from this to the internal canthal angle and the external canthal angle; these are cut each about 4 mm. from the line of lashes. An eighth skin incision is made at the external canthal angle, parallel to the line of the palpebral fissure slightly more than 3 mm. from the angle. Another is made on the same line of the angle but slightly more than 1 cm from it. Two others are made midway between these last two, one 6 mm above a line connecting them and the other an equal distance below this line. The most lateral of the incisions should descend to the periosteum, the others, with the exception of the first one, need only go through the skin and into the muscle fibers. The suture is now taken and the short stout needle passed through the internal canthal ligament This needle is immediately removed and the suture rethreaded with a needle similar to that on its opposite end. The two ends of the sutures are then threaded through the lid as follows: The upper of the two passed into the incision over the canthal angles is carried under the skin, at the level of the orbicularis fibers, out at *b*. It is immediately reintroduced into the same incision, again passing under the skin at a similar level to emerge at *c*. It is again reintroduced to emerge at the lower of the two incisions midway between *e* and *g* After emergence there, it is reintroduced at *f* to emerge finally at *g*, where the needle is removed. The opposite end of the suture is handled the same way in the lower lid. Both ends thus cross at *e* and are together at *g*. The needle on this end is not removed as yet Traction is applied to both ends of the suture until all of the loops are drawn into the incision lines and the palpebral fissure is closed to the width desired. The needle still remaining is now removed and replaced with that one which was used for passing the suture originally through the inner canthal angle. A secure bite with this is taken in the periosteum, through incision *g*, and the two ends are tied with a square knot. Care should be taken that the suture does not relax after the desired width of the palpebral fissure has been obtained, and before the knot is tied down. The ends are cut short and all of the incision lines closed with fine dermol sutures; *a*, *e*, and *g* will probably need two skin sutures because each of these incisions was made slightly larger than the others. The case is to be dressed with a ptosis dressing for forty-eight hours, this changed at that time and redressed again similarly for two more days. The dermol skin sutures can be removed at that time, the eye irrigated several times a day with boric acid solution or normal saline, and the dressing omitted.

If suppuration should occur in any of these tiny incision lines, it is rather likely that the infection will spread along the lids and it will be necessary to remove the suture. This complication has occurred to the writer. Rigid asepsis is necessary to assure the operator against the development of this secondary infection and nullification of the procedure. It seems that if infection should develop and the suture need removal that it might be reintroduced later.

Goldstein's operation[1] for non-cicatricial lagophthalmos attacks the

[1] Arch. Ophth., 11, 389, March, 1934.

condition upon the same anatomical grounds as used for correcting paralytic ptosis. In the presentation of his operation, the recession of the levator muscle for lagophthalmos, Goldstein calls attention to the various procedures at our command. He again quotes Naffziger and Jones[1] relative to orbital decompression. Those who have utilized this procedure are universal in emphasizing their (Naffziger and Jones) original recommendation. Their operation is not advised for persistent stationary exophthalmos. The indications for orbital decompression are: progressive exophthalmos, limitation of ocular movement; changes in the optic nerve; and impending corneal damage with the resulting loss of vision. Jaboulay, in 1896,[2] and later Mayo,[3] did superior and middle cervical sympathetic ganglionectomy. Mayo at the same time ligated the superior thyroid vessels. A Kroenlein osteoplastic resection of the outer wall of the orbit has also been done with equally good results. These procedures just quoted are for the serious progressive cases. Goldstein feels that his operation is ideal for the stationary cases. The clinical results he reported certainly bear this out. Figure 265, *A*, *H* and *I*, are the illustrations of a case sent by Dr. Goldstein. Figure 265, *A*, *A* to *G*, are the steps in his technique. It follows herewith, according to the originator.

Under local anesthesia (procain hydrochloride, 2 per cent, without epinephrine) the upper lid is everted and an Erhardt clamp applied with solid blade above. An incision, extending the entire length of the lid, is made through the conjunctiva only at the upper border of the cartilage. The upper flap of conjunctiva is freed upward from the underlying levator muscle for a distance of 10 mm. An incision is now made 1 mm below the upper edge of the cartilage, through the conjunctiva and cartilage to the fascia separating the levator from the orbicularis muscle. The cut edge of cartilage to which the levator muscle is attached is grasped and dissected from the fascia upward, for a distance of 10 mm. The levator being isolated, three double armed No. 5 silk sutures on a fairly curved needle ⅞ of an inch long, are passed through the levator. The suture is passed from within out, behind the strip of cartilage (which is later cut off), and brought out on the skin side immediately below the brow Three such sutures are passed and tied over "pigs." The cut conjunctiva is closed by a running stitch. The eye is dressed in two days, and if the cornea is intact the dressing is left off. The eye is then covered with a Gifford patch made of cellophane. The skin sutures are removed in four days, and the conjunctival sutures in one week. If the cornea has been the seat of an ulcer, the removal of the dressing should be postponed for a week. The operation may be similarly performed from the surface of the skin. By this method, the incision is made through the skin the entire length of the lid, at the upper edge of the cartilage, the globe being protected by a Jaeger horn plate. By blunt dissection, the orbicularis muscle is separated the entire length of the lids, exposing the levator muscle. A lacrimal probe is passed beneath the levator muscle, care being taken not to puncture the conjunctiva. The levator muscle is cut from its attachment and freed upward for a distance of 10 mm. Three double armed No. 5 silk twisted sutures are passed nasally, mesially and temporally, and are tied on the skin side just beneath the brow. The skin is closed by interrupted sutures. The eye is dressed in two days, and the sutures removed in five days.

[1] Surgical Treatment of Progressive Exophthalmos Following Thyroidectomy, Jour. Am. Med. Assn., 99, 638, August, 1932.

[2] Bull. Acad. de méd, Paris, 33, 139, 1897.

[3] The Surgical Treatment of Exophthalmos, Jour. Am. Med. Assn., 63, 1147, October, 1914.

LEGEND FOR FIG. 265 *A* AND *B*

FIG. 265 —*A*. Recession of the levator. (Goldstein, personal communication) *B*. Unilateral lagophthalmos on right with correction following recession of the levator palpebræ superioris.

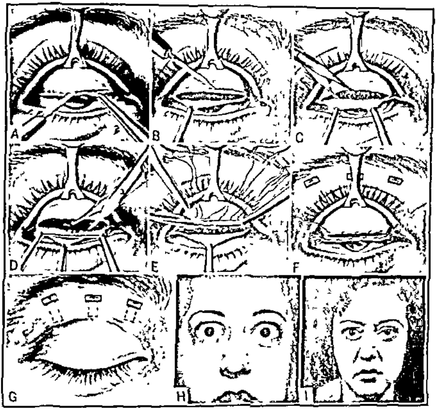


Fig. 265 *A*

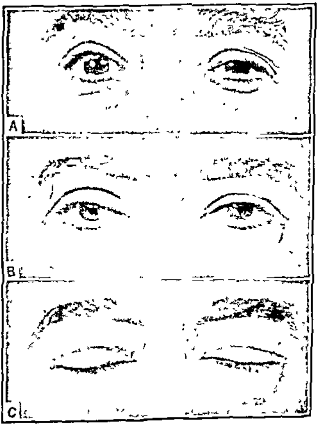


Fig. 265 *B*

Figure 265, *B* is a case of lagophthalmos before and after the Goldstein operation wherein the unilateral lagophthalmos followed several months after uneventful bilateral corneo-scleral trephining for glaucoma. The left eye failed to develop the condition. Neurologically the patient had a frank right-sided cerebral sympathetic irritation. Careful examination failed to show any cause for the condition. The surgical correction was quite satisfactory, and there has been no return of the lagophthalmos; also no recession of the slight right-sided exophthalmos. No thyrotoxicosis is present.

The correction of lagophthalmos from facial paralysis by strips of fascia or by means of buried white silk sutures is to be considered as well. Blair first recommended the use of fascia lata. Wiener utilizes these strips of fascia similar to the lower end of the Axenfeld suture; quite similar to Verhoeff's suture for ectropion. The writer has used the buried silk sutures with full satisfaction An incision is to be made through the skin along the ridge of the zygoma down to the periosteum. Three further incisions are then made: one at the external canthal angle, one halfway between this canthal angle and the angle of the mouth, and the third at the angle of the mouth. Each of these incisions needs to be about 1 cm. in length. Three silk sutures (stout No. 3 boiled white braided) or three strips of fascia lata, are then threaded upon long, straight, subcutaneous needles, and these passed from the first incision over the zygoma beneath the skin, rather deeply downward in a converging manner—one to each of the group of three later incisions. Here each suture is made to take a firm and secure bite in the muscle and subcutaneous tissues there. At the external canthus it is quite permissible to section the external canthal ligament, if desirable, to obtain even greater elevation. The suture is then returned, subcutaneously, to the original incision and there anchored, with equal security, to the periosteum of the zygoma after sufficient tension has been placed upon each suture for a satisfactory maximum correction. Figure 271 is an illustration of the end-result of such a procedure. The skin incisions are then closed with dermol as is usual. Extreme degrees of lagophthalmos can be further assisted by any one of the several tarsorrhaphies at our command, necessitating only a moderate degree of additional correction. In cases of complete eyelid paralyses, where peripheral nerve destruction is so extensive that recovery is impossible, Hunt[1] uses thin strips of cartilage inserted beneath the margins of reconstructed lids. Gillies used this method with a fair degree of success. In some cases the attempt was made to obtain a spring-like action by shaping the cartilage like a bow. Waldron has used a similar modification of the temporal muscle method by transplanting a very narrow strip of temporal muscle and fascia, completely encircling the palpebral fissure through small tunnels made in both eyelids close to the tarsal plates. This gives the eye greater protection and comfort by diminishing the vertical diameter of the palpebral fissure and markedly improves the appearance of the eye.

Cicatricial Lagophthalmos.—The more severe forms and the cicatricial form will often need extensive operative correction. Snydacker's operation for utilizing skin flaps from the neck may be used for the correction of this condition. The cervical flap is raised upon a non-tubulated pedicle and its correcting apex placed into a dissection formed for it in the upper lid. This

[1] Hunt: Plastic Surgery of the Head, Face and Neck, Lea & Febiger, 1926.

upper lid dissection allows a lowering of the level of the upper lid a sufficient amount to overcome the lagophthalmos. The normal appearance of the skin of the upper lid, however, is unlike that of any other portion of the body, therefore any graft implantations into the lid are likely to give a conspicuous result. This, however, cannot be avoided The author has tried free skin grafts from the opposite lid, and while they do improve the appearance temporarily, the end-result is unsatisfactory The skin from this region is entirely too elastic. Four months after the operation the graft had followed the course of the upper lid in its steady upward contraction due to the unopposed pull of the levator palpebræ A thin plate of cartilage had been tried upon one other case but this curled upon itself, from the slight but steady pull of the levator, throwing the lid into a definite ectropion. True skin grafts, that is a graft involving the entire thickness of the skin, are the most satisfactory. The skin is of sufficient thickness to add weight and bulk to the normal weight of the upper lid and still not stiffen the lid so that a subsequent ectropion develops, as with the attempted use of the cartilage. In one case, a non-cicatricial lagophthalmos, the case in which the cartilage was used, a tenotomy of the levator palpebræ superioris was done with good results This procedure, however, is *not recommended* because the condition may terminate in extensive ptosis.

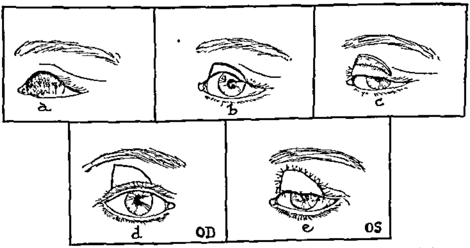


FIG. 266.—Drawing to outline the technique for correction of cicatricial lagophthalmos in case of Figure 267.

Figure 266 illustrates a technique, original with *Elschnig*, which can be utilized for colobomata, or for a more extensive lagophthalmos, in situations wherein the eyeball has been lost and one may use epithelium for the repair of the posterior surface of the lid. An incision is made through the skin surface of the lid above the limits of the defect (contracting cicatrix) (see Fig. 267), and the tissues lying between this incision and the residual lid margin so undermined that a flap, hinged at the lid margin, will be turned down to fill in this original defect. Such a flap could be a portion of a lid, either canthus, or consist of the entire lid still present depending upon the degree of lagophthalmos present or the size of the coloboma needing correction. The free edges of this flap are sutured into necessary

vertical incisions made, with silk mattress sutures, intermarginal sutures placed for adequate postoperative immobilization, a glass prosthesis or conformer placed into the socket, and the operation completed by a free skin graft, from the opposite upper lid, or taken from behind the ear, of proper size and shape and this sutured into position.

The technique has many modifications possible, and many different uses. It can be used, however, only when it is permissible to replace the posterior surface of a lid (upper or lower) with epithelium.

FIG. 267.—Cicatricial lagophthalmos.

Lagophthalmos because of trauma with resulting scar tissue contraction is more easily corrected. Here, pedicle flaps carried into a correcting position are quite satisfactory. Roy[1] presented a case of lagophthalmos due to scar tissue contraction, corrected by means of pedicle flaps. The photographs of the case are included (Fig. 268, A, B and C). In the presentation of this case the important and the new factor of the operative work

[1] Transactions International Congress of Ophthal., 1922.

not, as he himself stated, the manner in which the flaps were obtained, not the region from which they were obtained, but the use of certain stay sutures. At the time of the initial operation, in order to achieve an *immobilization of the canthus and thus prevent a later elevation of the canthus, through contraction from continued postoperative cicatrization,* catgut sutures were passed from the area of the external canthus, after its *replacement to a proper level, to the periosteum of the malar region.* The operation, as Roy did it, follows:

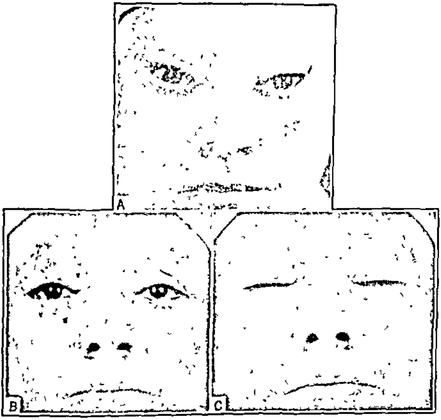


FIG. 268.—Pedicle flap correction of cicatricial lagophthalmos. (Courtesy of P. Blakiston's Son & Co.)

(The case was a scar tissue contraction lagophthalmos following partial scalping through trauma.) The operation, the left side first, was done under novocain and adrenalin. *A 5 cm. incision was made, ending a little* below and 12 mm. externally to the canthus. This downward incision was slightly crescentic and crossed the line of *the outer third of the deformed* eyebrow. By the dissection about the outer canthus, it was possible to replace the margin of the upper lid to a horizontal level. *The dissection* wound thus uncovered was filled in with a pedicle flap from a cheek, 7.5 cm. long and about 15 mm. wide, this being slightly larger than the wound defect to be covered. The new feature of this operation was then carried out. In order to immobilize the position of the canthus and at the same time prevent later postoperative scar contraction, a suture of catgut was passed from the periosteum of the malar region to the region of the dissec-

tion wound, and tied. The flap was then moved up from the cheek and sutured in place with silk. The incision on the cheek was next undermined and closed. The dressing applied exerted pressure from above downward, augmenting, as it were, the effects of the periosteal suture in holding the canthus in a proper position. The right side was then corrected by the same method. Figure 268, *B* and *C*, shows the amount of normal movement obtained as well as the slight amount of scar on the cheeks as a result of the operation.

Figure 269 is a case of lagophthalmos with entropion following an automobile accident. The patient still has 6/9 vision. The pedicle flap used for the correction in this case, *B*, was taken from above the eyebrow while the eye was still in permanent intermarginal adhesions. A hair line was grafted in from the eyebrow on the opposite side and the end-result as

FIG. 269.—Lagophthalmos from extensive lid tissue loss, no ectropion present. *A*, original defect, *B*, immediately after the pedicle flap; *C*, several months later.

seen is quite satisfactory. It seems that flaps taken from above the forehead leave less permanent scarring than when taken from the skin over the cheek.

A third type of lagophthalmos is occasionally seen. It is a complication of disease of the upper palpebral conjunctiva and in certain respects would correspond to a symblepharon. Entropion may complicate it to some extent. It is also possible for this to develop because of conjunctival burns. The author has seen it twice. One of them followed a tarsus extraction. Fortunately the correction of this is readily accomplished, because of the large amount of conjunctiva distributed upon the upper lid and the globe. A suitable crescentic incision is made above the limbus rather high up on the eyeball, and all the superior orbital and palpebral conjunctiva is carefully and slowly undermined until the conjunctiva

near the margin of the tarsal plate has been reached. The orbital conjunctival incision is then closed with two or three black silk sutures and the lids sutured together in a temporary tarsorrhaphy for six days. If necessary, it is possible to supplement this operation by two conjunctival flaps of bulbar conjunctiva, lifted from below the limbus and moved into an incision immediately above the limbus. A pedicle flap can be utilized upon the external surface of the lid at the same time, if necessary. The combination of cicatricial lagophthalmos with entropion must be corrected by a mucous membrane graft on the conjunctival surface. When complicated by ectropion a skin flap from the lower lid (shortening this, and further depressing the canthus) into the upper lid will almost always be necessary, as additional correction to complete the case to a maximum correction.

Exophthalmos.—Exophthalmos, surgically, is almost wholly a matter of the correction for the relative lagophthalmos which accompanies it. To recapitulate briefly, the procedures at our command are in general four in number. The first is to be applied to the lids in the form of a modified Fuchs' tarsorrhaphy or the use of Axenfeld's looped suture. Second, it is a consideration of cervical sympathetic resection and ligation of the superior thyroid vessels. The third, is some form of orbital decompression either by means of a Kroenlein orbitotomy, the orbitotomy of Shugrue-Moran, or the transfrontal intracranial decompression of the roof of the orbit; and the last is by means of a recession of the levator. All of these have been covered sufficiently (Chapter II).

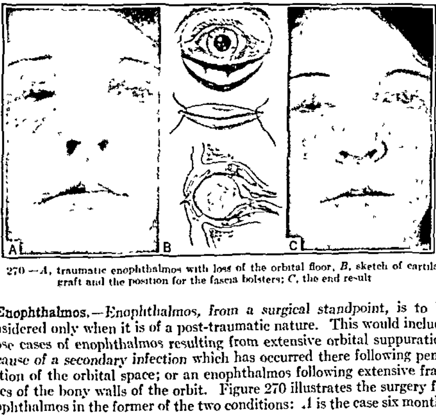


FIG. 270.—*A*, traumatic enophthalmos with loss of the orbital floor. *B*, sketch of cartilage graft and the position for the fascia bolsters; *C*, the end result.

Enophthalmos.—Enophthalmos, from a surgical standpoint, is to be considered only when it is of a post-traumatic nature. This would include those cases of enophthalmos resulting from extensive orbital suppuration because of a secondary infection which has occurred there following penetration of the orbital space; or an enophthalmos following extensive fractures of the bony walls of the orbit. Figure 270 illustrates the surgery for enophthalmos in the former of the two conditions: *A* is the case six months

after recovery from a severe suppurative cellulitis and tenonitis, post-traumatic. The patient had 6 9 vision in that eye and complained considerably of diplopia present in all positions except with fixation slightly to the right and slightly above the mid-line. *B* shows the fractured floor of the orbit. This was first corrected with a cartilage graft. A large Tenon's capsule graft was then taken from the thigh, cut into two equal parts, rolled up into a tight bolster, and the shape of this bolster maintained by two No. 6-0 plain catgut ties. The conjunctiva was incised 1 cm. above

FIG 271 —Traumatic enophthalmos corrected with a cartilage graft and pedicle flap for an accompanying ectropion. Buried silk sutures used for the facial paralysis.

the limbus and the internal edge of the superior rectus identified. The same thing was done over the external rectus and both superior and inferior edges of the external rectus freed. It was also done relative to identifying the internal edge of the inferior rectus muscle. A large, curved, aneurysm needle was threaded with plain No. 3-0 catgut suture and then passed with concavity downward, behind the eyeball from the internal edge of the superior rectus, the handle itself being swung up and inward, until the point of the needle appeared behind and below the inferior edge of the external rectus. The suture in the eye of the needle was grasped, the

needle unthreaded and withdrawn in a manner opposite to that by which it was introduced. A second suture was similarly passed from the medial edge of the inferior rectus to the superior edge of the external rectus. A rolled bolster of fascia was securely tied to the edge of each of these sutures as it emerged from beneath the superior and inferior recti. Traction was then applied to the end of the suture as it lay respectively either below or above the edges of the external rectus At the same time the bolster was grasped with a smooth tissue forceps and coaxed gently behind the eyeball into the muscle cone. As soon as the bolster seemed to be in proper position the catgut suture was cut free as far back as one could reach, with Stevens' scissors, and the conjunctiva closed with black silk sutures (*C* of Fig. 270). Both eyes were dressed and kept covered for six days The end-result was fairly satisfactory. The patient's eye was brought forward in the orbit an appreciable amount, as one can see from *C*, further field of binocular single vision moved toward the mid-line, and lay exactly in the mid-line and at 33 cm. was 10 degrees in cross surface. Ocular motility before the operation was practically *nil*. After the operation she had a few degrees of internal and external rotation. A year later the case was seen, and her field of binocular single vision had improved, at 33 cm., to almost 15 degrees upon the tangent screen

Figure 271 is a case of enophthalmos with extensive soft tissue defects resulting from an automobile accident. In this instance so much of the floor of the orbit had been lost that the maxillary sinus and the bony orbit were one cavity. The roentgen-ray shows the silver wire sutures used to anchor the large cartilage graft necessary in this case for the correction of the enophthalmos and the restoration of the floor of the orbit. The subsequent plastic surgery necessary was that of correcting the obliquity of the palpebral fissure. After the resection of the scar tissue, because of the ectropion, a pedicle flap was moved from the forehead into the lower lid. The relaxation of the face from an accompanying facial paralysis was improved by two buried white silk sutures as illustrated in the mid-line picture, lower row, of Figure 271. The end-result justified the surgery.

CHAPTER XI

SURGICAL CONDITIONS OF THE LIDS—CONTINUED

THE LID SURGERY OF TRACHOMA. TARSUS RESECTIONS. BLEPHAROPTOSIS

THE LID SURGERY OF TRACHOMA

THE conjunctival surgery of trachoma and discussion as to relevant chemotherapy will be considered later under the section on Surgery of the Conjunctiva. Also, at that time will appear a brief discussion as to the sulfa drugs in trachoma. Here it is relevant to consider trachoma only as it applies to a tarsus resection, for in the final analysis, trachoma is the greatest single indication for this procedure. Various operations have been presented: Arlt, Blaskovics, Gillet de Grandemont, the Heisrath resection and Kuhnt's modification of it, and van Milligan's technique for this surgery.

Tarsus resection is definitely indicated under certain circumstances. The development of pannus ceases and in many instances it disappears. The ptosis is corrected and the defects of the lid margin due to the deformed tarsal plate are cured at the same time. It is indicated always in those cases of trachoma which fail to respond to any other treatment. It is contraindicated if there is any limitation of conjunctiva in the superior cul-de-sac. Tarsus resection, simple or combined with the cul-de-sac resection, occasionally is indicated for the lower lid as well. Kuhnt,[1] who has performed more than 5000 tarsus resections, states that: combined extraction cures from 50 to 60 per cent of the cases; that secondary corneal disease is either prevented or quickly cured; and third, the mechanical ptosis is corrected and recurrences are less frequent.

The author has found that a simple tarsus resection can be done with satisfaction even in the presence of limitation of conjunctiva in the superior cul-de-sac by a careful conservation of the conjunctiva which lies in the fornix. With Beard's technique the operator makes an incision through the whole length of the tarsus 2.5 mm. from the free border of the lid, being careful not to injure the fascia underlying the orbicularis. The conjunctiva is then dissected from the tarsal plate with a sharp, slightly curved scissors, leaving the plate exposed. The plate itself is then separated from the pretarsal connective tissue up to the convex border of the plate by means of blunt-pointed scissors. Lastly, the plate is detached from the levator tendon. A few black silk sutures are sufficient. If ptosis is present it will become accentuated as the result of a simple tarsus resection.

The author has used Wheeler's and Barrada's technique for the combined resection (tissue and cul-de-sac) to the exclusion of all others. These two are given in detail herewith. Wheeler's operation will correct the accompanying trichiasis and ptosis as well as remove entirely the trachomatous tissue. The illustrations, Figure 272, are from Wheeler's original ones,[2] and are almost sufficient as an explanation of the operation. The

[1] Beard, Ophth. Surg., 2d ed., Philadelphia, P. Blakiston's Son & Co., p. 376

[2] Loaned with description of his technique to the author for publication in Newer Methods of Ophthalmic Plastic Surgery, P. Blakiston's Son & Co., 1925.

technique of Wheeler is as follows: The instruments necessary are Ehrhardt lid forceps, mouse-tooth forceps, scalpel, fine-curved scissors, needle-holder, and three double-armed silk sutures. In place of the Ehrhardt forceps the operation may be performed less conveniently by using a horn or rubber plate and fixation forceps. Novocain and adrenalin are injected into the tissues of the lid, and this is satisfactory except with an irritable eye. It is necessary to inject the solution into the tarsus itself as well as into the soft tissues of the lid. This can be accomplished by entering the tarsus with a hypodermic needle through the conjunctival surface as well as through the skin If general anesthesia is employed, adrenalin solution should be injected to control hæmorrhage The forceps are applied to the upper lid with the plate in contact with the skin, and the serrated edge in contact with the conjunctiva about 2 mm from the margin, and evert the lid An incision is made through the conjunctiva

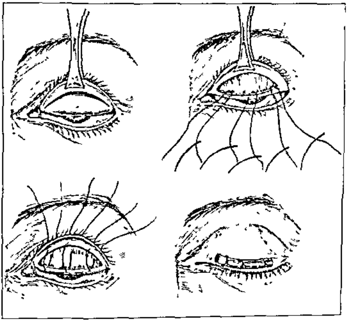


Fig 272 —Technique of Wheeler's tarsectomy.

and tarsus 2 to 3 mm. from the border of the lid throughout the entire length of the tarsus *The incision should not be carried into the orbicularis* muscle, for a brisk hæmorrhage will result from cutting the arteries that lie in this tissue. If the incision is carried through the tarsus and no further, very little bleeding will occur throughout the operation. The loose tissue between the orbicularis and tarsus is divided, and the tarsus, with its conjunctival lining, is cut free at its curved upper margin. If the operation is being performed for a ptosis of slight degree, it may be wise to leave a strip of the upper part of the tarsal cartilage While the lid is still everted, one of the two needles of each double-armed suture is introduced into the edge of the conjunctiva and tendon of the levator palpebræ superioris, and the needles placed carefully on a sterile towel on the face. One of these sutures should be in the middle and the other two equidistant from the middle and the ends of the wound. The sutures must not become crossed

or twisted. The lid forceps are removed and the lid allowed to assume its normal position. One needle of each suture, Nos. 2, 4 and 6, is carried through the orbicularis and the skin of the eyelid just above the tarsal rim at the edge of the eyelid. The other needles, Nos. 1, 3 and 5, are each carried through the entire thickness of the lid, including the conjunctiva and the tarsus just away (below) from the cut edge of the tarsal rim. This will bring the edge of the conjunctiva and the levator tendon to the cut edge of the tarsal rim without causing overlapping and without irritation to the eyeball from the sutures. These are then tied over a roll of gauze upon the skin surface of the lid. A dressing may be kept on from three to six days and the sutures removed on the seventh day. In old trachoma cases the operation will correct the accompanying ptosis and trichiasis as well as remove the trachomatous cul-de-sac.

Another satisfactory tarsus resection is the combined tarsus resection of Barrada.[1] It is based upon the results of 325 operations and, according to Barrada, it is indicated in trichiasis and entropion due to a bending deformity of the tarsal plate; in trachoma which fails to improve under the usual forms of treatment; for spastic entropion following cataract operations or after purulent conjunctivitis; for trachoma with extensive pannus; and for diseased and degenerative conditions as cysts and tumors of the tarsal plate. Cocain is injected over the lash-bearing area, this being the seat of pain, the lid everted and an incision made at a line between the healthy and the unhealthy conjunctiva. A second incision is then made parallel to the lid margin, as close to the line of lashes as possible. Barrada is particular to remove as much of the tarsal plate as is possible, especially at the outer third of the lid, to prevent later drooping or other deformity. The internal canthal ligament is then cut with scissors and the tarsal plate and conjunctiva removed, the operator being careful to press the points of the scissors always against the posterior surface of the tarsal plate to prevent damage to underlying tissues. The removal of the tarsal plate in this manner prevents ptosis, for injury to the levator, or even its partial removal, will result in a postoperative drooping of the lid. This complication will not develop if the dissection is properly carried out. The lid is then released from its eversion and the remaining conjunctiva undermined well into the superior fornix. Mattress sutures are then passed from the edge of the remaining conjunctiva, one of the needles emerging just behind the roots of the lashes, the other as close to the cut edge of the lid as is possible, but neither passing through the lid margin itself. These are loosely tied to furnish accurate approximation of the conjunctival edges. Three or four such sutures are necessary. If the sutures are tied too tightly, or even worse, introduced so that the knot lies too far from the edge of the lids, a postoperative entropion will result. In this operation, as in all tarsus resections, injury to the palpebral lobe of the lacrimal gland will result in a lacrimal fistula. (If this should occur it would need later removal.)

The fact that ptosis does not follow this operation depends wholly upon the normal anatomy of the levator tendon insertion: The tendon is attached (*a*) to the orbicularis palpebrarum fibers by an upper lamella, (*b*) to the posterior surface of the tarsal plate by a middle lamella of the tendon aponeurosis, and (*c*) to the conjunctival fornix by a lowermost layer. In addition (*d*) there are definite terminal horns of this aponeurosis attached

[1] Trans. Ophth. Soc. of United Kingdom, 39, 401, 1939.

to the inner and outer canthal (palpebral) ligaments. During the operation *b*, *c*, and *d* are severed. As the tendon insertions into the canthal ligaments, under normal conditions, prevent excessive action of the levator, two very positive factors remain to prevent ptosis, the integrity of the superior lamella and the removal of the check action upon the canthal ligaments.

Wheeler's technique, when applied to the lower lid and combined with the author's sutures, is most satisfactory. The entire plate here need not be removed, but sufficient must be resected to correct the entropion and thereby remove the real cause of the entropion. At the same time, the diseased conjunctiva immediately posterior to the line of lashes can be simultaneously resected. The remaining conjunctiva immediately posterior to the line of excision is elevated to the limbus and into the two canthal angles. The cut edge of this undermined conjunctiva is then brought to the marginal line of the tarsus resection by a series of double-armed sutures, each end of these sutures being passed from the conjunctival surface toward the lid margin, one end exactly to the line of resection, the other end slightly posterior to this. Five or six such sutures are necessary. These are then tied and their ends cut short. Three additional stouter sutures are then passed from the conjunctival surface toward the lid surface, to emerge 8 mm. below the lid margin. These sutures carry the undermined conjunctiva down into a cul-de-sac to the greatest distance possible for the conjunctiva present, and assist further in the correction of the entropion. The latter sutures are tied through pearl buttons on the lid surface.

The treatment of severe vernal conjunctivitis by non-surgical means is oftentimes most unsatisfactory. In many instances neither medicants nor radium therapy gives a cure. This is especially so in people who have yearly recurrences. The partial excision of the tarsus as just recommended for trachoma using Axenfeld's technique, the technique of the combined Kuhnt-Heisrath, of Wheeler's or Barrada's technique, all give considerable improvement and occasionally a complete cure. Actually, however, as was pointed out by Shimkin[1] in Spring Catarrh the tarsus of the lid is usually quite healthy. The affection involves only the conjunctiva and subconjunctival tissue because of the abnormal growth in the conjunctiva with its accompanying hyaline degeneration. In view of this, it is only necessary to carry out a careful excision of the conjunctival and subconjunctival tissues from the surface of the tarsus beginning at the lid border, and replace this with the healthy conjunctiva from the superior fornix. Shimkin calls his operation "Anterpositio Conjunctivæ Fornicis," for the conjunctiva of the fornix is drawn forward to the tarsus after it has been freed from its morbid conjunctival and subconjunctival tissue.

The operation of Shimkin is as follows: Threaded needles are inserted in the skin of the lid border and brought out along the intermarginal line. One suture is made on the margin of the middle and the outer thirds of the lid border; and the other suture, on the margin of the middle and the inner thirds. These two sutures are very convenient for strong retraction of the lid turned upwards on Yaeger's spatula. These sutures do not touch the conjunctiva at all, and therefore, all the lid border conjunctiva, affected with papillar growth, is clearly seen. These sutures do not hinder the removal of the conjunctiva at its very margin which is impossible when applying any force to the lid margin. An incision is made 2 mm. below the

[1] *Trans Internat. Cong. Ophth.*, 4, 12, 1937.

demarcation line, dividing the affected tarsal conjunctiva from the healthy conjunctiva of the fornix. The line of demarcation of the healthy conjunctiva of the fornix blanched with adrenalin, stands out clearly, if the lid is drawn tightly on Yaeger's spatula. Immediately after the incision, the bulbar part of the conjunctiva contracts. The subconjunctival tissue, denuded after the incision, is shown in figures as a wide black strip. Immediately after the incision in the conjunctiva, 3 loop sutures are applied on its bulbar part in its superficial layers, 1 mm. away from its border; one loop suture in the middle, one on the margin of the middle and outer thirds,

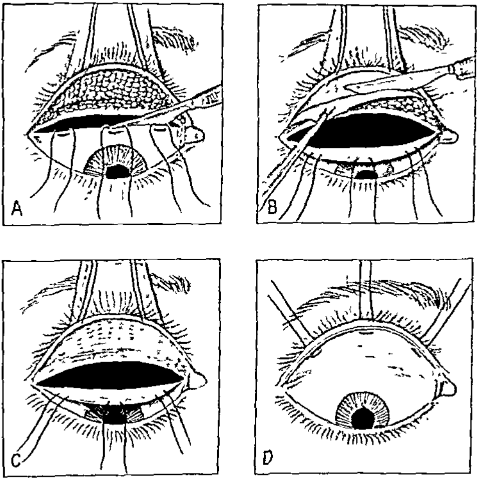


FIG 273 —The illustration of Shimkin's technique for conjunctival cul-de-sac resection and reformation in vernal conjunctivitis (Shimkin, courtesy of Trans Intern. Congress)

and one on the margin of the middle and inner thirds. (Fig. 273, *A*.) There, loop sutures should correspond to the middle and to the outer and inner thirds of the lid border. The conjunctiva thus separated should be thin and not contain any underlying tissue. This separation of the conjunctiva should be continued by means of blunt-headed scissors; and should be deep enough, so that the conjunctiva may freely cover the denuded tarsus. The tarsal conjunctiva affected with papillar growth is removed from the very border along all its surface, by means of saw-like movements with a sharp scalpel laid flat side down. In Figure 273, *B*, the everted part of the tarsal

conjunctiva with the underlying tissue is seen. Immediately after removing the conjunctiva the normal tarsus is seen with the Meibomian glands glimmering clearly through its substance.

Usually, all the conjunctiva separates easily from the tarsus, from top to bottom, along its surface. The surgeon should take exceptional care that no traces of the affected conjunctiva and subconjunctival tissue are left on the border and surface of the tarsus

If, by separating the conjunctiva from the tarsus, the Meibomian glands *are not glimmering clearly through its substance, then it is a pathognomonic* sign, that the tarsus is not healthy and most likely is affected by trachoma in different stages not recognized before the operation. In such a case it is better to cut out the tarsus and perform a classical Kuhnt-Heisrath combined tarsus excision. The needles of the 3 loop sutures are inserted 1 mm away from the border of the conjunctiva, the width of the loop of each stitch on the exterior side of the conjunctiva being 2 mm.; the loops lie *on the middle of the conjunctiva and on the outer and inner third* Each needle of each loop stitch is pierced into the thickness of the tarsus 1 mm away from its edge and is carried slantwise, so as to pass out among the eye-lashes. In Figure 273, *C*, is clearly seen: (1) the position of the loops on the conjunctiva, (2) their exit among the eye-lashes. Each needle is to pass slantwise *in the thickness of the tarsus and have compact tissue along* all its course.

After inserting all the 6 needles, the sutures are tied drawing the healthy fornix conjunctiva forward on the denuded cartilage. Figure 273, *D*, clearly demonstrates the result of the operation and position of the transplanted conjunctiva. After the operation, a bandage (binocular) is placed on both eyes for 2 days. On the third day the sutures are taken out, and again a bandage is applied for another two days.

CLASSIFICATION AND SUBDIVISION OF PTOSIS

Congenital Ptosis

From the standpoint of its correction, congenital ptosis still continues as the stepchild of ophthalmology. Not so long ago, it shared this peculiar distinction with strabismus. In recent years, however, physicians seem less certain that children will outgrow a squint.

In a large percentage of instances congenital ptosis, even when recognized by the parents or physician, is still permitted to continue uncorrected, in the hope that nature will work a miracle for the child. Although hard to believe it is a fact that in too many instances ptosis is not recognized before the child is three years old and even later in life. Not infrequently histories obtained from parents prove this to be true. If diagnosis and treatment are established in the fourth year, the fifth year, or even the sixth year, the end results may not *be too inadequate, but* when a sixteen-year-old child of a physician reports for the surgical correction of this condition with a visual acuity of 5/500—a now practically intractable amblyopia in that eye—then one is fully justified in thinking that carelessness is also a factor.

Congenital ptosis, excluding certain complicated cases (see Figs. 274 and 275) is a result of congenital developmental *defects in the levator and* superior recti muscles and with their innervations. A rather inconstant *familial relationship* is involved. The cosmetic blemish alone of unilateral

or bilateral ptosis of the upper lid or lids as the result of a simple levator muscle nerve impairment should be of itself sufficient to demand correction before the child develops amblyopia from impaired vision, awareness of the defect, shyness, introspection and an inferiority complex.

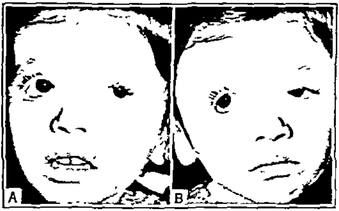


FIG. 274 Congenital ptosis of upper lid on left, with congenital lagophthalmos of upper lid on right.

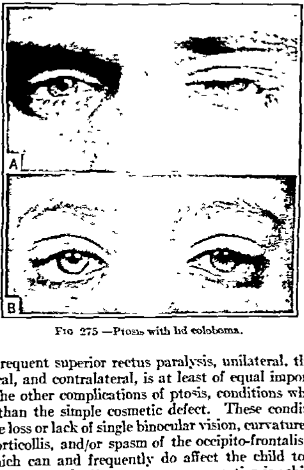


FIG 275 —Ptosis with lid coloboma.

The not infrequent superior rectus paralysis, unilateral, that is, homolateral, bilateral, and contralateral, is at least of equal importance in the causation of the other complications of ptosis, conditions which are even more serious than the simple cosmetic defect. These conditions include amblyopia, the loss or lack of single binocular vision, curvature of the spine, epicanthus, torticollis, and/or spasm of the occipito-frontalis. These are conditions which can and frequently do affect the child to a profound degree, even when mental adjustment or compensation is achieved. Occa-

sionally, the child fails to develop necessary mental and physical adjustments adequately.

The problem of developing single binocular vision in the infant is so definitely one of the development of balancing conditioned reflexes which depend upon the absence of pathological sensory and motor obstacles, that one is not astonished at the appearance of torticollis, of amblyopia, of indocility, and of all types of situation and compensation neuroses and even psychoses.

An analysis of private and clinic cases of blepharoptosis seen over the past twenty years yields nine subdivisions as a basis for the following classification of this condition, with the percentage incidence, as well, for each subdivision.

Class 1.—Unilateral ptosis without superior rectus involvement Included are 7 cases in which there was amblyopia of 6/22 or less, 1 case with torticollis (The torticollis suggests a paralysis of a vertical acting muscle) (See Fig 276)
40 per cent of all cases

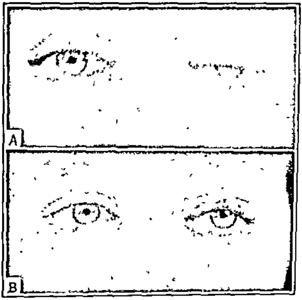


Fig 276 —Unilateral ptosis before and after surgery

Class 2.—Unilateral ptosis with involvement of the homolateral superior rectus these cases included 4 cases with amblyopia of 6/22 or less and 2 cases with torticollis. (See Fig. 277.)
21 per cent of all cases.

Class 3.—Bilateral ptosis *without superior rectus involvement*; in one case there was a unilateral amblyopia of less than 6/22.
7 per cent of all cases.

Class 4.—Bilateral ptosis with bilateral superior rectus involvement. In 4 instances the superior rectus involvement was one-sided *only*; in 2 cases there was torticollis. (See Fig. 278.)
8 per cent of all cases.

Class 5.—Unilateral ptosis with weakness of both superior recti; more marked, however, in the homolateral eye. Five such cases have been seen; in 2 there was

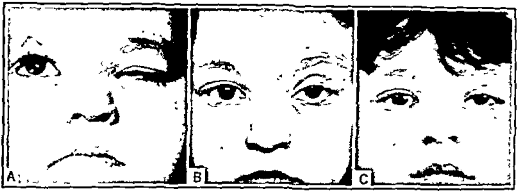


Fig 277 —Unilateral ptosis with an accompanying superior rectus paralysis O.S. Both muscle and lid surgery are necessary.

Fig 278 —Bilateral ptosis with bilateral impairment of the superior recti muscles.

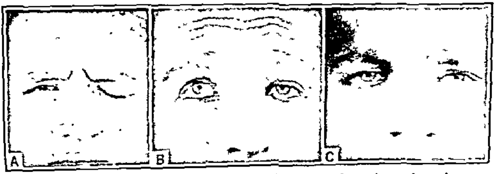


Fig. 279.—Unilateral ptosis with impairment of the bilateral superior recti muscles.

torticollis and some amblyopia. One patient maintained fixation usually with the eye that had the ptosis; that is, the left eye. A secondary deviation, right eye, with fixation maintained in the left eye because of its better vision, was the cause of the diplopia. In another case there was an almost complete ptosis and in the third marked fibrosis of the homolateral inferior rectus. (See Fig. 279.)

2 per cent (plus) of all cases.

Class 6.—Ptosis with more or less complete third nerve and even sixth nerve paralysis; 4 of these cases were bilateral cases, and 5 others were unilateral. In 5 of these cases there was torticollis; in 1 unilateral case, in a young lady aged twenty years, there was amblyopia with vision of less than 1/100. Her degree and type of squint (divergent) was that of a strabismus fixus. In another unilateral case possible inferior and superior rectus paralyses existed. In one unilateral case the internal and the superior rectus were involved; in a second there was ptosis with the left internal rectus impaired, and in the third the superior rectus was impaired homolaterally with a fibrosis of both inferior recti. Another patient had ptosis on the left lid with paralysis of the external rectus. (See Figs. 280, 281, and 282.)

9 per cent of all cases.

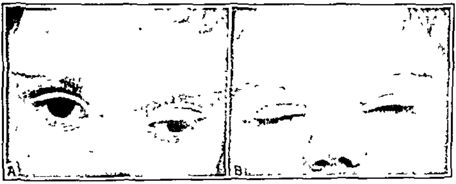


FIG. 280.—Ptosis with an almost complete third nerve palsy congenital.

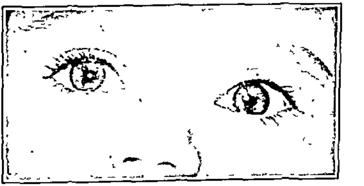


FIG. 281.—Same case as that of Figure 280, two years following surgery to left upper lid and left eye muscles.

Class 7.—Ptosis with the classical jaw-winking reflex; the Marcus-Gunn syndrome of misdirection of developing fifth cranial nerve and tracts and oculomotor nerve fibers. According to Bing and Haymaker (5th ed., St. Louis, C. V. Mosby Company, p. 589, 1939), "The Marcus-Gunn phenomenon occurs not only in cases of congenital ptosis, but also in individuals with acquired ptosis and in some who are free of ptosis. According to Helfreich and Berkhard, this phenomenon can be explained only on the basis of neuronal intercommunication between the nuclei of the facial, trigeminal, and oculomotor nerves. Such an intercommunication

has been recently denied by Lewey, Groff, and Grant. These authors state that the Marcus-Gunn phenomenon is completely abolished by section of the motor root of the trigeminal nerve but that with forcible movements of the jaw postoperatively the associated movements of the eyelid could still be elicited. This suggested to them the presence of a proprioceptive reflex arc, the afferent limb of which is the sensory portion of the mandibular division of the trigeminal nerve. They assumed that the efferent part of the arc—that passed to the eyelids—was via autonomic fibers whose pathway was undetermined but thought to be via the ophthalmic division of the trigeminal nerve." The author cannot agree with this hypothesis, considering the third nerve motor innervation of the levator, and judging from the many other not uncommon cranial nerve, pathological, intermingled syndromes seen, congenital as well as acquired. Nevertheless, the question is answered as unsatisfactorily by postulating the presence of brain stem internuclear communications, as suggested by Helfreich and Berkhard.

FIG. 252.—Congenital ptosis with congenital paralysis of the contralateral internal rectus muscle.

The observations of Lewey, Grant and Groff can be answered upon the basis of Cannon's law of denervation. This states (Walsh) "that postganglionic and to a lesser degree preganglionic section of a nerve results in increased sensitivity of the innervated structure to the chemical mediator, whether or not that substance is sympathin or acetylcholine. The sensitivity persists providing that regeneration does not occur and that the innervated structure does not become atrophic." Hence it seems rather unnecessary to assume a proprioceptive reflex arc, with its efferent portion still intact, as the reason for the condition. Their observation is possibly correct. This same thing, however, was seen in a feeble-minded individual who became emotionally upset when chided (strong elevation of both lids), and Walsh saw it in a patient in whom the lid became elevated invariably whenever he lost temper or became interested in an attractive member of the opposite sex. One wonders why this syndrome cannot be caused by the congenital misdirection of developing peripheral nerve fibers, the faulty distribution occurring in the posterior longitudinal bundle, without brain stem neuronal internuclear communications. Certainly this seems plausible when one considers the many vagaries of the pseudo-Graefe syndrome; as the ultimate termination of fibers destined for the inferior oblique appearing in the sphincter pupillæ; and perhaps the results which can be obtained by surgical anastomoses of facial nerve, hypoglossal nerve, and spinal accessory nerve. (See Fig. 142.)

3 per cent of all cases.

Class 8.—Ptosis with the Duane retraction syndrome. Both instances were undiagnosed until the tenth year of life; at least, they were not seen by a physician. In a case not included herein there was ptosis only on right lateral rotation in an eye, the left, which also had a congenital sixth nerve paralysis. It is not a case of

retraction syndrome (though with some enophthalmos) nor a strabismus fixus (See Fig. 140.)
2 per cent of all cases.

Class 9.—Ptosis with neurofibromatosis. In 14 cases of orbital plexiform neurofibromatosis, ptosis was present in 10 instances to a marked degree due to the neoplastic infiltration and to destruction of, or interference with, the levator (See Fig. 283.)
10 per cent of all cases. (This incidence is high—but these cases are not usually nor primarily included in a discussion of congenital ptosis.)

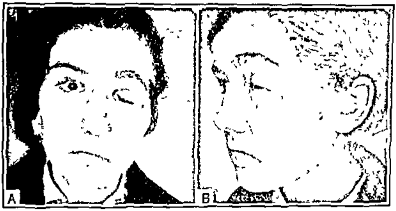


FIG 283.—Ptosis with neurofibromatosis

In an analysis of these cases, as to incidence, it is proper to omit those of neurofibromatosis, for they are not related in incidence, nor in cause. This done, it is seen that in a very few less than 100 cases operated for congenital ptosis, the following significant and interesting factors appear. Approximately 75 per cent are unilateral and 30 per cent are bilateral Of the unilateral cases, approximately 25 per cent were complicated; that is, other factors of clinical significance were involved besides the cosmetic blemish of the drooping lids. In almost all of the cases of bilateral ptosis, there were exaggerated epicanthal folds, especially in the younger patients, and in addition to this, 37 per cent were complicated by factors other than the epicanthus and the bilateral drooping of the lids. Epicanthus, alone, is a condition which should not be treated surgically until the patient has reached adult facial growth, for many of these instances correct themselves spontaneously when and as that growth is reached. Instances may arise, however, in which the degree of epicanthus is so severe that some corrective surgery is indicated before that time. Some of these eyes have varying degrees of trichiasis. This must be corrected at an early date.

Some other congenital defects are to be noted, such as external canthal defects, ankyloblepharon, epiblepharon, primary epicanthus of high degree, lid colobomata, and others, which may have an accompanying ptosis. In these cases, however, this is only secondary to the plastic defect, and usually not of neuromuscular origin.

In studying these arbitrary anatomical subdivisions of congenital ptosis, one must agree that several of the classes overlap. Even though Classes 5 and 6 are not too dissimilar, and although together they represent approximately 10 per cent of all cases, they still are sufficiently unlike to be listed as has been done.

Because of these several close approximations, the classification already made can be simplified to some extent for the final anatomical subdivision, as follows: The surgery indicated in the various cases is, however, an important factor in favoring the more extended and earlier classification.

Class 1. No change; 40 per cent of all cases.

Class 2. To include Class 5 of the former division; 23 per cent of all cases.

Class 3. No change; 7 per cent of all cases.

Class 4 To include Class 6 of the former division; 17 per cent of all cases.

Class 5. Jaw-winking cases.

Class 6. Retraction-syndrome cases.

Class 7. Neurofibromatosis and all such congenital plastic defects as those aforementioned. If these are included as such, however, it will change to a marked degree the percentage incidence of the true ptosis cases as mentioned herein.

BLEPHAROPTOSIS

Blepharoptosis, more commonly spoken of as ptosis, is the inability to raise the upper lid due to paralysis or paresis of the levator palpebræ superioris muscle. It may be either congenital, following trauma, after inflammatory conditions of the orbit, or a part of a partial or a complete external ophthalmoplegia. The paralysis need not be complete—simply present to such a degree that the weakened muscle is unable to raise the lid against the resistance of the orbicularis oculi muscle, plus the weight of the lid itself. Cicatrices in the upper lid simulate a ptosis frequently, but as long as the levator palpebræ superioris is not paralyzed, the correction of these conditions is simply a matter of scar tissue resection and suture, permitting the levator again to function as it should.

As Beard[1] stated, in abstract, all who have had much experience in this branch of ophthalmic surgery will agree that the results of ptosis operations, taken all in all, are far from brilliant. It is only with precise appreciation of the peculiarities of the individual case that one may hope to succeed in this delicate and special surgery of the lid (Terson). A correct diagnosis as to the character of the ptosis and a nice estimate as to its degree are requirements for satisfactory outcome. The high degrees of congenital ptosis, with inert superior rectus, are the most difficult with which to contend. It is in these that, according to Beard's observation, the greatest good is to be looked for from those surgical measures that do not rely for their success upon a simple feature or principle, but upon a well considered union of two or more. In this manner one is not obliged to so exaggerate a particular step as to risk, for example the production of unsightly and harmful lagophthalmos, but is enabled to obtain a maximum effect with a minimum disturbance of any one of the several parts involved. For the milder forms of partial ptosis and in well selected cases all the measures to be described readily give satisfactory results in good hands.

Referring to the anatomy of the lid, for ptosis, we must consider three muscles of importance: (1) the levator, (2) the superior rectus, (3) the occipito-frontalis. The levator has been fully discussed, page 354. The

[1] Beard, Ophthalmic Surgery, 2d ed., P. Blakiston's Son & Co., 1914.

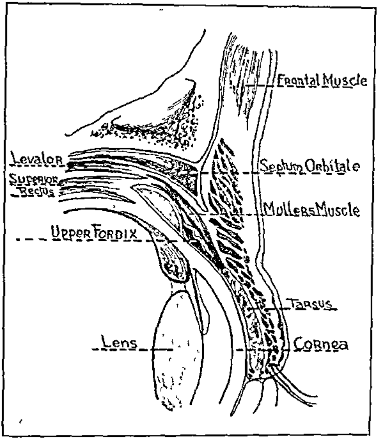


Fig. 284.—Intimate relationships which exist, in detail, between the levator, the superior rectus, and the occipito-frontalis

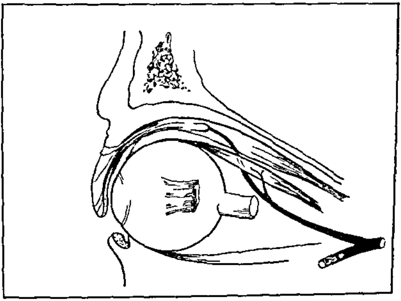


Fig. 285.—The nerve supply to the muscles concerned in Figure 284.

superior rectus is histologically and embryologically in close association with the levator (Figs. 284 and 285) and the occipital frontalis is truly an accessory muscle of lid elevation, and as such is to be frequently utilized.

Ptosis must be divided into two types of cases, those without and those with a surgical relationship. Most of the cases requiring operation are congenital. These are the most classical of cases with a surgical relationship. A progressive and recent isolated paralysis of the levator muscle alone, however, is to be corrected surgically only when all other means of treatment have failed. This type of ptosis lies in the borderland between surgical and non-surgical indications. One would not consider the surgical correction of a ptosis resulting from an intracranial neoplasm until everything possible for the neoplasm had been done and the case is in the condition of a more or less permanent cure. The same thing applies to a complete external ophthalmoplegia, unilateral or bilateral. In such instances diplopia would result and the cornea probably will be lost from consequent exposure and drying. The ptosis of myasthenia gravis is probably the best example of an absolute contraindication to surgery. In this the degree of ptosis is always changing. Cases are present where there is no ptosis. Other intervals will occur when the ptosis is practically complete. In spite of this, and perhaps because of it, surgery is contraindicated.

The Jaw-winking Reflex. The Pseudo-Graefe Phenomenon. (The Misdirection of Regenerating Third Nerve Fibers. The Marcus-Gunn Syndrome)

These two major conditions (see jaw-winking reflex) are surgically treated quite similarly. The first of the two is a congenital situation involving developmental misdirection. The second of the two is a post-traumatic affair wherein, during the process of recovery, misdirection of regenerating third nerve fibers occurs. Figure 142 is such an illustration.

In these conditions the outstanding ophthalmological problem is the variability in the ptosis. At times it is present to a marked and disabling degree. At other times and under certain circumstances not only is the ptosis not present, but there may actually be a lagophthalmos present. They are to be converted into a completely paralytic form of ptosis by the wide resection of the levator. The lid is everted upon itself, the conjunctiva incised along the upper margin of the tarsal plate, the levator fibers isolated and then sectioned not only from the tarsal plate and from the pretarsal space but also from the superior conjunctival cul-de-sac. In addition one must be careful to section down toward each canthal angle and toward each canthal ligament so that the lateral horns of the levator are cut as well. The conjunctiva is then closed and a proper period of recovery allowed to intervene. The cases are thus transferred into a completely paralytic form of ptosis. The second stage in this surgery is some type of orbicularis procedure, preferably the Reese, or through the use of a fascia sling to the orbicularis.

Inoperable ptosis can be improved decidedly by the use of crutch glasses. The procedure is one of simple mechanical support. Figure 286*a*, *A* and *B*, shows a case of complete bilateral external ophthalmoplegia where operation was quite out of the question because of danger to the cornea through subsequent exposure; *A* is the case without her glasses, *B* with her crutch

glasses in place (this patient has worn these for over ten years at the present time without any corneal damage whatsoever), these crutch glasses which are worn by the patient have elevating loops attached to the upper rim of

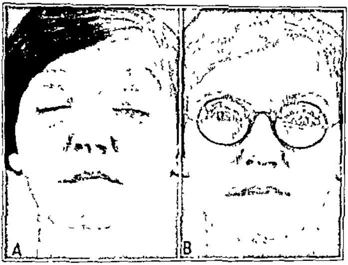


Fig. 286a.—Crutch glasses for complete external ophthalmoplegia (*Am Jour Ophth*, vol 15 No 7, July, 1932)

the spectacles, of such a size, shape, height, and posterior concavity that the lid is elevated with the loop as the glasses are placed upon the face. The loops are made of silver wire and that portion in contact with the lid is

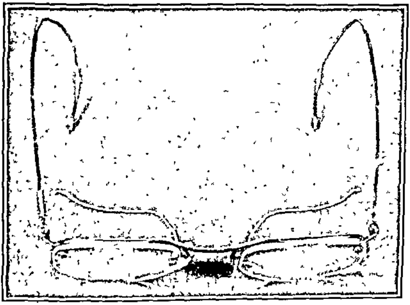


Fig 286b.—Crutch glasses Note flat temple spring hinges and flat spring crutch

covered with zylonite tubing. The mechanical manufacture of it can be done by any capable optician. Dodge[1] presented an improved lid crutch

[1] Arch. Ophth, 14, 989, December, 1935

which he claims is quite applicable to selected cases of paralytic and spastic cases. The crutch is inconspicuous and should be readily worn. A substantial gold filled frame with a pad bridge is fitted to the patient. A pair of box studs is soldered to the frame at the point where the leverage is most suitable. This point varies with each patient. As Dodge states:

The contour of the superior orbital ridge and the nose as well as the position of the eye in the socket enters in the location of these studs. A piece of piano wire sufficient for the weight of the ptosed lid is used This is bent with a curvature that will fit into the fold of the upper lid The wire is then bent to give greater freedom for adjustment and carried to and looped around the screw of the stud.

Fig. 287 —Complete external ophthalmoplegia postencephalitic.

Dodge covers that portion of the wire which is in contact with the skin of the upper lid with zylonite or enamel. A vertical hinge joint, with an overlying leaf spring, on the temple near its junction with the frame, gives added comfort to the patient.

If these glasses are made with a tempered flat spring-hinge where both crutch and temple join the frame, the patient will have considerable relief and greater ease of normal blinking. Figure 286*b* illustrates this type of flat spring hinge and Figure 287, a patient wearing them. This is a case of complete external ophthalmoplegia.

Operative Ptosis.—There are four general procedures at our command: shortening of the eyelid itself; advancement alone, or advancement with resection of the levator; replacement of the levator by the occipito-frontalis; and, the utilization of the superior rectus.

The first of these is usually quite unsatisfactory. Some correction is obtained from a tarsectomy but only in very moderate degrees of ptosis.

and in the final analysis this actually is a levator advancement. Simple skin resections are futile for, if sufficient skin is excised to correct the ptosis, lagophthalmos and ectropion will develop. The three remaining procedures are to be seriously considered, but each type of operation is best applicable to certain definite cases No one of the three lends itself to all of the cases which appear for correction. Further, unilateral ptosis must be handled differently from bilateral ptosis. The ptosis of infants, whether bilateral or unilateral, must be treated quite differently than that of adults or even that of older children. Cases of ptosis with some levator action still present should be operated by some method which utilizes this to its fullest extent.

The number of operative procedures which have been presented are innumerable. Some of them are delightfully simple and usually of no great value, and others are rather complicated and do not offer unusually good results to compensate for the difficulties present in the technique outlined.

The ptosis of infants must be corrected, especially if bilateral, as soon as the infant begins to walk. The child will throw his head back and develop thereby a faulty posture due to hyperextension of the head, neck, and spine, which is quite distressing to see. Crutch glasses may be used here as a stop-gap. The author has done this with full satisfaction, in this way being able to postpone the ptosis operation until the fourth or fifth year of the infant's life. Unilateral ptosis cannot be operated by the utilization of the superior rectus muscle. The Motais-Parmaud procedures for this are founded on sound physiological and scientific bases. If the operation is successful for the correction of ptosis, however, a unilateral hypophoria is almost certain to develop. The absence of such hypophoria probably means an unsuccessful ptosis operation. Further, there are other factors connected with the Motais operation which must be considered. Success in its application depends upon the normal integrity of the superior rectus. A large number of cases of congenital ptosis are accompanied by an insufficiency or even paresis of this muscle. Hence, a careful study of the ocular rotations upward must be made before the operation. Terrien recommends perimetric investigation and measurement of the degree of ptosis in every case under consideration. The patient's head is placed on the chin rest of a standard perimeter, with the head fixed so it cannot be tilted backward. The lid is then lifted with the finger tip, and the eye follows a luminous point carried along the arc of the perimeter to measure the number of degrees of upward rotation possible from fixation The observer should be immediately behind the point of light as it moves along the arc of the perimeter (the light from an electric ophthalmoscope with a condenser over the globe is ideal for this), at the same time keeping the reflection of this light in the center of the pupil of the patient. Maximum upward elevation has been reached as soon as the light moves out of the pupillary center. According to Peter, 35 to 40 degrees of upward rotation is normal. The lid is then released and the patient again follows the light upward. This time, however, the reflection of the point of light is kept upon the edge of the lid. The total amount of lid elevation is thus ascertained. It is evident that the amount of upward rotation of the eyeball in degrees must be appreciably greater than the amount of lid elevation in degrees. During

24

this determination the patient must not be permitted to lift the lid by using his occipito-frontalis muscle.

The original Motais procedure calls for the dissection of a central tongue of muscle tissue from the superior rectus, this to be transplanted into the upper lid for a twofold purpose: (1) to hold the upper lid open, and (2) to permit further elevation of the upper lid as the eyeball is rotated upward. It is absurd for one to think that this tarsus-superior rectus adhesion functions as a strip of muscle. It can only act as a cicatricial adhesion of the tarsus to the superior rectus. If this is believed and considered seriously, then the rationale for some of the more recent modifications of the ptosis operation, as Kirby's and Shoemaker's modifications, is logical. The deepening of the orbito-palpebral fold which occurs with the Motais operation is quite satisfactory. The eye is rather prone to remain open, however, following the Motais during sleep, doing so with this operation more than with any of the other operations. The reason for it is plain. The upward rotation of the eyeball, which is physiologically present in sleep, must also elevate the adherent lid. Winking, further, may be rather difficult following this operation. The eyeball ordinarily remains fixed during the process. The attachment of the upper lid to the superior rectus now limits this in that the movement of the upper lid is quite dependent upon the movement of the superior rectus.

Surgery applied to the levator is ideal. Two conditions, however, qualify the permissibility of surgery to the levator. Cicatrices, cicatricial contractions, and stab wounds and lacerations which have already sectioned the levator are contraindications. There should be some levator action present to obtain ideal results. The futility of surgery upon the levator as "an all around procedure" lies in the fact that in a great number of cases the muscle is either absolutely inert or so insignificant in its power that satisfactory correction may not occur. Lindner,[1] in his discussion of the Blaskovics operation for ptosis, felt that even in complete paralysis of the levator, the shortening of this muscle plus the tarsectomy gives results which are adequate for the greatest number of cases. Considering our classification in such instances, this must necessarily be a combination of two of the basic principles mentioned: (1) a shortening of the lid itself, and (2) surgery upon the levator.

Surgery which utilizes the occipito-frontalis has no effect on the levator palpebræ superioris. As Beard states:[2]

> The frontalis owes its power of lifting the eyebrow to the fact that its attachment is essential to the skin; hence, procedures that call for deep or extensive incisions and other traumatisms in the superior ciliary region, must result in scars that inevitably limit the natural movement of the parts.

The utilization of the occipito-frontalis, when properly used and with the proper indications, is a very nice procedure. For unilateral ptosis, however, it does result in a peculiar facial grimace not wholly beautiful to view. Further, the occipito-frontalis is rather likely to contract bilaterally in the largest number of cases. Hence, with unilateral ptosis the palpebral fissure of the normal eye would be widened. Still this fault, while unfortunately present, does not contraindicate the utilization of the occipito-frontalis when proper indications are present.

[1] Klin. Monatsbl. f. Augenh., 93, 1, July, 1934.
[2] Ophth. Surg., 2d ed., P. Blakiston's Son & Co., p. 246.

Principles of Surgical Correction for Congenital Ptosis

The most important factor to be considered is the matter of surgical correction. Surgery for the oculomotor complications follows the established rules in force for paralytic strabismus, modified only by the following features: the presence of torticollis, for that indicates a struggle against diplopia; the identity of the fixating eye, for squint may be manifest because of a secondary deviation; and the danger involved in correcting a vertical deviation; namely, of destroying all vertical elevators while attempting to eliminate this vertical defect.

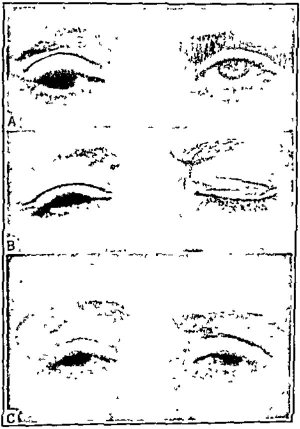


Fig. 288.—Earlier correction improper technique used, see text for description

Levator advancements, with or without tarsectomy, demand some percentage of still-intact levator action, otherwise the immediate surgical result will not remain as the permanent result. Levator surgery may be performed at any time after the second year of life. Superior rectus surgery, that is, the Parinaud-Motais principle, is never to be performed as a unilateral procedure. In bilateral levator and superior rectus procedures it is proper to operate on both upper lids at the same time. The latter operation, however, should be put off until the third year of life, if possible, *simply because a three-year-old child is easier to control postoperatively.* The postoperative adjustments and demands in superior rectus surgery are, in addition, more exacting than are those following the levator surgery.

The three main principles connected with ptosis surgery are all applicable at various times in these cases; namely, the use of the occipito-frontalis, the use of the superior recti, if they are normal, and a shortening of the levator. No one operation will take care of all of these cases. A properly selected procedure will always give better results than any procedure selected unwisely or in error, no matter how brilliantly it may be executed.

Figure 288 illustrates such a situation. The upper photograph, eyes to the front, shows the ptosis after it had been corrected ten years prior to the date this picture was taken. The patient had a paretic superior rectus. (This can be seen by careful scrutiny of the photograph.) In spite of this a Motais operation was performed, not only upon a paretic superior rectus, but also as a unilateral procedure. The patient had photophobia, and vision was tremendously reduced from corneal scarring due to an exposure keratitis. The middle photograph, showing the eyes closed, illustrates the constant exposure due to this procedure. The lower photograph is of the same patient immediately after resection of the superior rectus and the upper lid adhesions, an advancement of the superior rectus, and a simple levator advancement. It is tragic, but true, that these situations are constantly being seen not only as unilateral, but as bilateral cases.

In general, ptosis classified under 1, 2, 4, 5 (the first suggested Classification Table) and only occasionally 9, are best corrected by means of a levator advancement, usually with a partial tarsectomy.

The tarsectomy is the advancement portion of a levator procedure, whereas that section of the levator tendon aponeurosis that is removed is the shortening factor in the operation.

The latter is always necessary, the former usually so. Ptosis classified under 9 may be an exception. In Class 4, dissimilar degrees of ptosis may call for differences in the amount of the tendon resection but if a tarsectomy is to be done, this should be equal in amount in both lids. Cases in Class 5 may not always fit into this category, and some cases in Class 6 may occasionally come within its limits.

If no levator action whatsoever is present in these individuals, the surgery must utilize the occipito-frontalis. This is especially important in younger patients. Linder stated that with complete levator paralysis, after adult life, a levator advancement may be performed in the knowledge that the shortening of the tendon plus the tarsectomy will be followed by a permanent cicatricial support of the formerly ptotic lid. The writer concurs in this opinion.

Ptosis classified under 3, is the ideal situation for the Motais-Perinaud technique. There are several satisfactory modifications of this technique; the one which the author likes best is the Shoemaker modification. Class 6 may occasionally fit into the limits indicated for this operative technique.

Eyes in Class 6, and in Classes 1, 2, and 4 which have complete paralyzed levators are to be corrected by either a Gifford operation, a Hunt-Tansley procedure, or by the Reese technique of transplanting fibers of the orbicularis. The presence of any great amount of epicanthus may compel the use of the Gifford technique in which the correction is closer to the canthal angles. After late childhood, one can always resect these cicatricial tracts of the occipito-frontalis and then use any other procedures desired, if indications at that time have changed. The author is partial to the Reese technique.

For ptosis classified under 6, early extra-ocular muscle surgery is of great importance and should be completed satisfactorily before the ptosis itself is corrected. If not, one may find two difficulties arising: (1) a struggle against the reëstablishment of diplopia, and (2) some return of the formerly corrected ptosis. Surgery for the eyes in Classes 7 and 8 should be a complete tenotomy with tenectomy (resection but without reattachment) of the levator, and several weeks later, a Reese transplant of orbicularis fibers to the occipito-frontalis. In performing this tenectomy the surgeon must be careful that he also cuts free the lateral horns of the levator where they are attached to the canthal ligaments. Eyes in Class 7 may at times also need this operation; those in Class 8 as well, if the ptosis that remains after the resection of the fibrosed extra-ocular muscle suggests that fibrosis is also present in the levator muscle and its aponeurosis.

The condition of the eyes in Class 9 is a true plastic defect of the lid and should be corrected, after removal of the neoplasm in the greater number of instances, by the Hess technique. It may, however, be possible at times to reattach the levator. If this is the case, the operator may find that he must transplant a piece of ear cartilage into the lid to replace the lost tarsus, otherwise lid notching will develop during elevation of the upper lid

Recapitulation of Ptosis Surgery.—From the standpoint of the available techniques for the correction of congenital ptosis as compared with acquired ptosis, and excluding the operations necessary for the various oculomotor complications, the following procedures are recapitulated as indicated.

If utilization of the occipito-frontalis is contemplated, one must consider the Gifford modification of the Machek operation, the Hunt-Tansley operation, and the Reese orbicularis transplant: the Gifford is indicated for complete ptosis wherein epicanthus is a distinctive feature, and for slightly older children; the Reese for the jaw-winking reflex; and the Hunt-Tansley for all other cases within this subdivision of indications. The various other forms of this basic technique, such as Lexner's principles and the Hess introduction of Pagenstecher sutures, the Panas operation, the direct use of fibers from the occipito-frontalis (Robert's technique for the Freeland Fergus operation), Dransart's use of absorbable material, including fascia lata according to Derby, Wiener, and even Dickey's operation, are all proper procedures, but their indications lie in the field of acquired ptosis, especially ptosis connected with other plastic defects of the lids and the tissues immediately adjacent to the lids.

Indications for the utilization of the superior recti muscles are much more restricted, *i. e.*, this method is permissible within narrower limits. The operation is for bilateral conditions only if both superior recti are still present and functioning as such. The modifications of this procedure for congenital ptosis which the author considers as outstanding are Kirby's and Shoemaker's; either may be used, and bilaterally, at the operation. Young's operation is essentially the same as Shoemaker's, though presented later. Dickey's superior rectus fascia lata transplant is not required for congenital ptosis. It has been used, however, by the author in acquired ptosis for the elevation of the reconstructed lids (both flap and free skin graft corrections) and with beautiful results on older patients when earlier surgery had unfortunately included the resection of considerable amounts of the skin surface of the lids (see Fig. 289).

The firm attachment which this operation affords lends itself well to the heavy upper lids in such situations. Gifford's recent modification of this procedure is apparently most valuable. His procedure is to operate through a skin incision, and he passes the fascia slip under the entire superior rectus muscle rather than utilizing the middle third only. The Wheeler levator superior rectus operation should apply to this same class of cases. Further, these two operations might well be considered as reoperation techniques in instances wherein earlier surgery had either failed or yielded insufficient correction, considering always that the superior recti are normal in function. The Trainor operation, also a levator superior rectus procedure has only simplicity and rapidity of technique to offer, with other more important factors against it; nevertheless its two virtues might indicate its use under not uncommon circumstances, such as the permanent ptosis of cerebrovascular affections in older patients.

FIG 289 —The Dickey technique as a re-operation in old uncompletely corrected ptosis. Upper photo, preoperative, lower photo, the patient at the time of her discharge from the hospital.

When properly selected, levator advancements, with or without resections, have the greatest possibilities in cases of congenital ptosis. Inversely, their usage in acquired ptosis is relatively unimportant, except in two conditions. The ptosis of old enucleations is beautifully corrected by the external route resection, the Everbusch operation, and in partial traumatic section of the levator. This external route operation probably applies best in cases of unilateral acquired ptosis wherein some levator action is still residual; also when such cases are further complicated by other plastic defects not involving the loss of soft tissue or by cicatricial contractions such as: neurofibromatosis, at times; bony defects of the orbital wall; the ptosis of chronic trachoma; and after symblepharon corrections. It can also be used after reoperations wherein a Hess procedure has had to be undone, to permit a more satisfactory cosmetic result.

A summarization, therefore, of the procedures indicated for ptosis would in general give a classification similar to that in Table 4.

The utilization of one or more procedures in a single case is not at all uncommon. This is especially so when one considers the correction of the complicated forms of ptosis. Cicatricial ptosis, ptosis following longstanding enucleations, trachomatosis ptosis, and ptosis with neurofibro-

TABLE 4 SURGICAL INDICATIONS FOR PTOSIS

Condition present	Unilateral	Bilateral
(a) Infants up to the age of three years.	Crutch glasses	Crutch glasses.
(b) Children three to five years of age.	1 Hunt-Tansley procedure, utilization of occipito-frontalis 2 Robert's ptosis operation.	1. Hunt-Tansley procedure, utilization of occipito-frontalis 2 Modification of Motais 3 Robert's ptosis operation
(c) Children five to fifteen years of age	1 Blaskovics if levator action is present 2 Hunt-Tansley	1 Blaskovics 2 Modification of Motais.
(d) Adults uncomplicated and with levator action present	Blaskovics or some modification of levator advancement	1 Modification of Motais 2. Blaskovics or some modification of levator advancement.
(e) Adults bilateral without levator action but with superior rectus intact		1. Modification of Motais 2 Resection with advancement of the levator. (See Lindner's treatment)
(f) Adults — unilateral without superior rectus or levator action of any degree Acquired paralysis	1 Use of fascial sling (Reese) 2 Hess direct anchorage to occipito-frontalis 3 Hunt-Tansley (all are utilization of occipito-frontalis 4 Everbusch operation.	
(g) Adults—bilateral without superior rectus or levator action of any degree Acquired paralysis		1 Resection with advancement of the levator. (See Lindner's treatment) 2 Use of fascial slings. 3 Bilateral Hess
(h) Children with acquired paralyses and without accompanying external ophthalmoplegia Correction depends upon the degree of involvement.	1 Utilization of sutures which form permanent cicatricial tracts (mild degrees) 2 Hunt-Tansley operation 3 Hess operation	1. Utilization of sutures which form permanent cicatricial tracts (mild degrees). 2 Hunt-Tansley operation. 3 Bilateral Hess operation.
(i) Adults — with above condition as in (h). (correction depends upon degree of involvement).	1 Utilization of sutures which form permanent cicatricial tracts 2 Utilization of fascial slings 3 Hess operation	1 Utilization of sutures which form permanent cicatricial tracts 2 Utilization of fascial slings. 3 Bilateral Hess operation.
(j) Ptosis with incomplete external ophthalmoplegia.	1 Utilization of sutures which form permanent cicatricial tracts 2 Crutch glasses 3 Hess operation.	1 Utilization of sutures which form permanent cicatricial tracts 2 Crutch glasses 3 Bilateral Hess operation.
(k) Ptosis with complete ophthalmoplegia	Crutch glasses	Crutch glasses.
(l) Cicatricial ptosis.	1 Scar resection and suture 2. Lid shortening operation (Everbusch operation).	The Reese technique.
(m) Ptosis following longstanding enucleations.	1. Blaskovics or some similar levator muscle procedure 2. Lid shortening operation (Everbusch operation).	
(n) Trachomatous ptosis	1. Tarsus resection with advancement of the levator.	1. Tarsus resection with advancement of the levator.
(o) Ptosis with neurofibromatosis	1. Tumor resection 2. Hunt-Tansley with resection of redundant tissue. 3 Hess operation.	

matosis are illustrations of these. Frequently a ptosis remains following socket reconstructions and following extensive blepharoplasties. While these can be included in the four just mentioned, it is relevant to call the reader's attention to them as well. The selection of the operation which is to be used for an individual case is perhaps the most important point in ptosis surgery. None of the procedures is especially difficult. If an improper or illy-advised operation is used wrongly in a single case, the best technique in the performance of the operation will not give as satisfactory results as the proper operation might give even if done with less surgical finesse.

SHORTENING OF THE LID

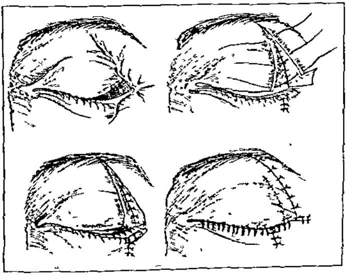
Skin Resection.—Beer was the first, apparently, to excise a portion of the skin of the lid for the correction of ptosis. It is of no great value. Even a ptosis following a long-standing enucleation will not respond to this form of surgical therapy without throwing the lid margin into ectropion. The Everbusch operation which is so often considered as the classical operation for lid shortening is actually an advancement of the levator and will be included therein as is proper. A rather similar qualification applies to the utilization of sutures in the correction of ptosis. These are also not really a shortening of the lid, they are simply a utilization of the occipito-frontalis by the formation of buried cicatricial bands. A true shortening operation is that which one performs in the correction of cicatricial ptosis. Figures 290 and 291 are of such a case. The levator had been completely cut. In addition to the paralytic ptosis there was accompanying it a cicatricial ptosis due to the dense band of thick cicatrix. The technique of *B* illustrates sufficiently the resection of the cicatrix and the suture of the lid in "staggered" layers. After this was completed it was necessary to resect a full thickness crescentic strip of skin, tarsus and fascia (the outer half of the tarsal plate) to obtain the opening in the lid which is seen in *C*. One could speak of the technique almost as an incomplete Everbusch in that while the Everbusch routine was carried out there was no hope for a return of lid motion. The simple removal of the cicatrix would not have been sufficient for the correction of the ptosis of this individual. In some instances, however, it would have been adequate.

In lid shortening operations, following blepharoplasties, it is necessary that the position of resection be closed in two layers, a line of catgut sutures for the buried stitches and of black silk for the skin. After the skin crescent has been removed the operator should place four deeply inserted plain catgut sutures in pairs above and below the position from which the lid tissue is to be removed. These should not penetrate through the lid to appear on the conjunctival surface of the superior fornix but should be placed so deeply that they stop just short of this. It is not necessary to resect conjunctiva in these instances. A portion of the superficial edge of the tarsus can be clipped off through the skin incision on the lid surface without disturbing the conjunctiva of the posterior surface of the lid. As soon as the tissue has been resected from the thickness of the lid, these catgut sutures can be tied immediately one to the other above and below the excision line so that there is no upward retraction of the paralyzed levator or the levator fascia. The immediate correction obtained is also the final result. One can, therefore, estimate accurately at the operating

table the degree of resection necessary and the amount of correction desired. *With the exception of this procedure, all other shortening operations are valueless.*

FIG. 290.—Cicatrix resection with skin shortening Case shown is a razor cut injury. (Courtesy of Jour Am Med Assn)

A *B*



C *D*

FIG. 291.—Technique of operation for case shown in Figure 290 (Courtesy of Jour. Am. Med Assn.)

ADVANCEMENT OF THE LEVATOR

There are two procedures at our command for this. The one corrects the ptosis through the skin surface, that is the Everbusch technique; the other advances and shortens the levator through the conjunctival surface of the lid, this is the Blaskovics technique. Each has its indication; cases for the Everbusch technique, however, while the indications are more insistent, appear much less commonly. It is ideal for unilateral post-traumatic paralytic ptosis wherein the trauma has been directed to the tissues of the eyeball. Next in value is its application to the correction of ptosis following long standing enucleations. Figures 292 and 293 show a complete ptosis following an automobile accident with late osteomyelitis of the inner angle of the orbit. Sequestrectomy and dacryocystorhinostomy were done for this, and an Everbusch operation was utilized for the correction of the ptosis. The end-result is satisfactory. This operation is most satisfactory for the ptosis following an early enucleation, as one which was done in childhood. A bone ball implant into Tenon's capsule is first to be done, and after that an Everbusch ptosis operation can be performed.

The object of the Everbusch operation is to shorten the muscle itself and to advance its attachment within the lid substance, thus holding that which was in part obtained by the shortening. It is not contraindicated if all levator action is lost, though naturally the more levator action still present the more satisfactory will the results be.

The operation can be done under local anesthesia. Instillation of cocain into the conjunctiva cul-de-sac must be augmented by novocain-adrenalin injection into the lid substance through the skin surface for superficial infiltration plus nerve blocking. Meller's[1] description is closely followed herewith. A lid plate is placed beneath the lid and a longitudinal crescentic incision, convexity upward, made through the skin of the lid and the orbicularis muscle midway between the arch of the eyebrow and the border of the lid. The incision should extend the entire length of the lid and pass down to the edge of the tarsus. The edges are then undermined below to expose the upper border of the tarsus, and above the tarsal orbital fascia and the tendon of the levator. The fascia is incised horizontally 6 mm. above the tarsus and the levator identified. If this cut is made too low, it will lie over the conjunctival fornix and escape the muscle, and if made too high, the orbital fat will protrude, making it difficult to proceed with the operation. Three catgut sutures are passed through this muscle and fascia with generous bites, the first one in the mid-line and the other two laterally to this. All should be placed at the same level in the levator fibers. The muscle is then cut through 2 mm. below these sutures, along the entire length of the lid incision and a piece of the lid excised from 3 to 5 mm. in width. This should include a small piece of the tarsus itself as well as the conjunctiva of the superior fornix, or of that portion of the conjunctiva which comes within the area of the piece to be excised. Figure 293 shows the technique of the dissection and the catgut sutures in the levator fibers. Each suture is passed through the anterior surface of the tarsus below its upper cut edge. There they are tied and their ends cut short. In this way the cut end of the muscle is brought forward upon the anterior surface of

[1] Meller, Ophthalmic Surgery, 3d ed., P. Blakiston's Son & Co., 1923.

the tarsal plate. The skin wound is closed with interrupted silk sutures as shown. These three catgut sutures may be replaced by three waxed black silk sutures if one wishes, and the sutures, after they have taken a bite in the anterior surface of the tarsal plate, continued under the skin of the lid to emerge on the lid margin just posterior to the line of cilia. If so they are to be tied over tiny pearl buttons or through glass beads.

In all of these ptosis operations the author completes his surgery by the introduction of a stout black braided intermarginal suture through the lower lid, according to Frost. This is passed just posterior to the line of lashes in the lower lid margin and includes from the point of entrance to its point of exit, at least 6 mm. of tissue. By traction upon this suture, at the time of the postoperative dressing, the lower lid is pulled up across the cor-

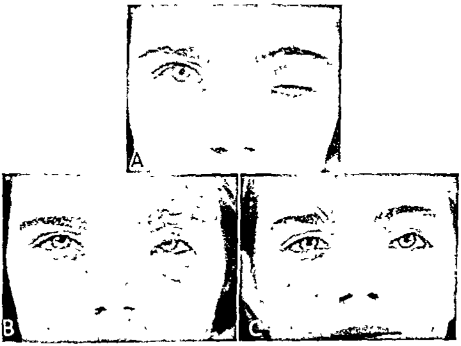


FIG. 292.—Everbusch technique in an illustrative case. Post-traumatic ptosis, completely paralytic with osteomyelitis. Case was completed with the author's operation for epicanthus. (Courtesy of Jour. Am. Med. Assn.)

nea, protecting it from damage through exposure during healing and at the same time acting as a support to the operated upper lid. The suture should be firmly anchored to the skin of the forehead.

If this suture is used, a Buller's shield dressing need not be utilized. If not, a classical ptosis operation dressing must be applied. Several thicknesses of gauze are placed over the operated eye, these having a central perforation corresponding to the open palpebral fissure. Sterile white petrolatum is carefully placed in this opening and a glass watch crystal or Buller's shield filled with sterile white petrolatum is placed directly over the perforation of the gauze. The watch crystal and the gauze dressing are held in place by three wide strips of adhesive and the entire dressing secured and reinforced subsequently by a bandage. In applying this bandage the operator should stand in front of the patient with a roll of bandage in the hand cor-

responding to the eye which is being bandaged. Twelve inches of bandage are draped obliquely *over the unoperated eye, the roll of bandage then* carried to above the operated eye, held there in place by the thumb of the opposite hand, folded upon itself and carried around the patient's head toward the unoperated side above the ear and below the occiput, so that this reflected tail of bandage hanging loosely over the unoperated eye is anchored in place. The bandaging is then continued by passing around the

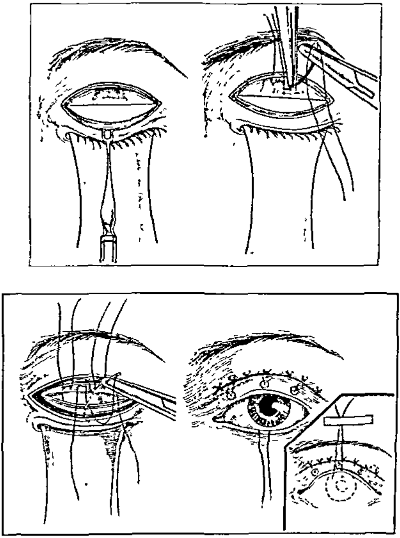


Fig 293 —Technique of operation for case shown in Figure 292. (Courtesy of Jour. Am. Med. Assn)

head above the ears with each alternate turn coming from behind the occiput beneath the ear on the same side and across the temporo-parietal region of the opposite side. *In this way the next turn about the occiput* anchors that turn which has just come up across the eye from below the ear on the operated side. The last two turns of the bandage should be about the forehead and the occiput, ending above the operated eye. The tail of bandage which had been draped across the unoperated eye is now

lifted and the two ends of the bandage firmly tied together above the operated eye. This gives a closely applied secure dressing exerting as much pressure as the operator desires and it permits the unoperated eye of the patient to open and close freely. Ptosis cases, under ordinary circumstances, should be dressed for the first time forty-eight hours after the operation and daily thereafter. Occasionally a secondary infection will occur in the sutures of the upper lid. When this occurs these sutures must be removed, and if the infection is at all extensive all dressings must be discarded and hot compresses and irrigation instituted to prevent extension of the infection and to conserve the results obtained by the operation. The Frost lower lid suture should prevent the development of a corneal ulcer. Care must be taken that this suture is firmly anchored to the forehead because if it relaxes the cornea will be uncovered. Further, an even more serious complication may develop in that the superimposed dressing may force the loops of this corneal suture into intimate contact with the corneal epithelium and traumatize the cornea thereby. The Buller-shield-petrolatum ptosis dressing, while a rather "messy" dressing, especially in hot weather, may be used in addition to the Frost suture if it is felt advisable.

Boucheron, in 1888,[1] Hugo Wolff, in 1896, and Elschnig and de Lapersonne, in 1903, also presented operations involving tarsectomy and levator shortening based upon Everbusch's technique which was originally presented in 1883.[2]

The Blaskovics ptosis operation was first described by Blaskovics in 1923. Since then Lindner[3] has been the greatest exponent in recommending this technique. Local or general anesthesia may be used. If local is being used, no more than 1 cc. of nococain or adrenalin should be injected into the region of the upper tarsus border from the skin surface and into the region of the levator palpebræ superioris from the conjunctival surface. If more than this amount is used, landmarks will be rather badly obscured. The upper lid is everted and the upper tarsal edge now lying everted is grasped by either a lock or double-action fixation forceps. The conjunctiva is incised parallel to and immediately at the tarsus border for the entire length of the lid. Three double-armed waxed braided silk sutures are placed through the cut edge of this conjunctiva from the external or mucous membrane surface (these are the sutures which finally pass through the cut end of the levator and out to the skin of the upper lid just above the lid margin). By traction upon these sutures and with dissection the conjunctiva is freed to the superior fornix and across the fornix to the superior limbus. Both sharp and blunt dissection may be used for freeing the conjunctiva. One must be certain that fascial fibers are not adherent to the conjunctiva; also that all cul-de-sac levator muscle fibers are released. Three temporary white silk sutures, to be used only as traction sutures, are next placed in the levator near its tarsal attachment, care being taken not to include the fascia in the sutures, and one must be certain that they do not pass through the full thickness of the lid. When placing these sutures, the surgeon must be careful to include also those levator muscle fibers dissected from the superior fornix. With the help of the traction sutures, the

[1] Arch. d'Ophth., 8, 289, 1888.
[2] Monatsbl. f. Augenh., p. 100, 1883; and Breicht über die Versamml. i Heidelb., p. 146, 1893.
[3] Klin. Monatsbl. f. Augenh., 93, 1, July, 1934.

levator is carefully freed from the fascia after cutting it loose from its normal attachments to the tarsus. In this way the levator is mobilized as a flap of muscle tissue which can be followed back into the orbit. The tarsus is not undermined upon its conjunctival surface. A 3 to 5 mm. tarsectomy is then performed. This includes both tarsus and its overlying conjunctiva. The resection of the levator fibers is to follow next. Before removing this section of the levator the exact amount for resection is determined by estimating the width of the palpebral fissure desired when the operation is completed. From 8 to 15 mm. of levator tissue is the amount usually resected, 1 cm. being the average. If the levator has been partially effective before operation a slight undercorrection is required. Assuming that 10 mm. is to be resected, the three white traction sutures are held taut while the three black braided silk conjunctival sutures are passed through the muscle from the posterior surface outward, one after the other, the middle suture first, and the two laterals subsequently, 11 to 12 mm. above the cut

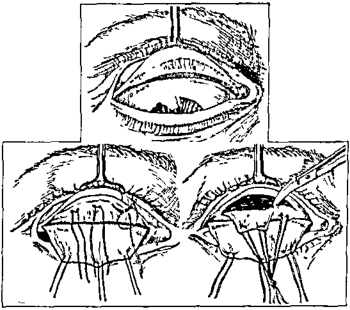


FIG. 294 —Blaskovics ptosis operation, first step.[1]

free end of the levator muscle. In this way these three black silk sutures lie entirely through the muscle and back of the line of section. The muscle tissue peripheral or distal to these sutures is now removed with scissors and discarded. The temporary white silk traction sutures have made it possible to free the levator with ease, to place the black silk sutures accurately through the muscle tissue, and if all are held with equal tension, the resection of the levator fibers can be done quite smoothly and evenly. Here again the operator is warned to make sure that the black silk sutures as they pass through the levator muscle do not also pass through the skin of the lid. Lindner recommends that the middle of the three sutures be placed through the muscle 1 to 2 mm. further forward than those on the side, the shortening thus being somewhat less in this middle region, preventing a subsequent sharp arching of the lid margin. The braided silk sutures are

[1] Figures 294-299: Lindner, Klin Monatsbl. f. Augenh., courtesy of Ferdinand Enke.

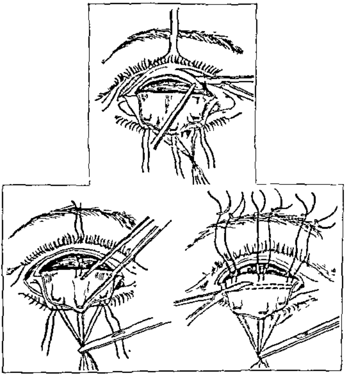


FIG 295.—Blaskovics ptosis operation, second step.

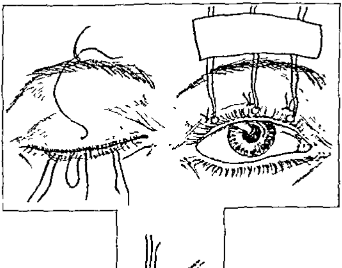


FIG. 296.—Blaskovics ptosis operation, third step.

now passed through the eyelid immediately adjacent to the cut edge of the tarsus emerging upon the eyelid surface just above the line of cilia. In this way conjunctiva and muscle are brought up to the cut surface of the tarsus, reforming smoothly the superior cul-de-sac and advancing, at the same time, the insertion of the levator. These sutures are to be tied through tiny glass beads or preferably through tiny pearl buttons. The normal eyelid fold (orbito-palpebral fold) is formed by a second row of three mattress sutures of black twisted silk passed from the posterior conjunctival surface of the eyelid through the thickness of the lid in a line parallel to and slightly less than midway between the eyelid margin and the supraorbital ridge. Lindner passes these sutures from the muscle surface only

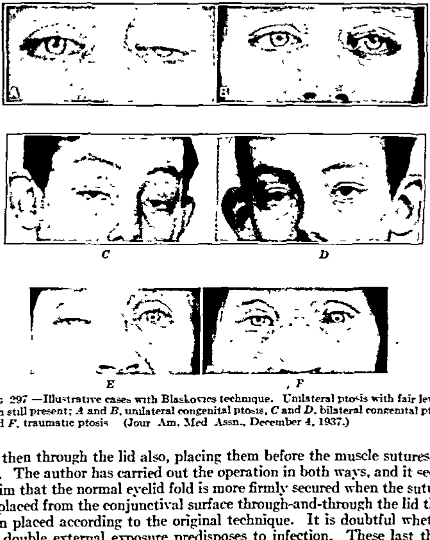


FIG 297 —Illustrative cases with Blaskovics technique. Unilateral ptosis with fair levator action still present; *A* and *B*, unilateral congenital ptosis, *C* and *D*, bilateral congenital ptosis; *E* and *F*, traumatic ptosis (Jour Am. Med Assn., December 4, 1937.)

and then through the lid also, placing them before the muscle sutures are tied. The author has carried out the operation in both ways, and it seems to him that the normal eyelid fold is more firmly secured when the sutures are placed from the conjunctival surface through-and-through the lid than when placed according to the original technique. It is doubtful whether this double external exposure predisposes to infection. These last three sutures need not be tied over glass beads. The long ends of the muscle sutures are pulled upward and fastened above the eyebrow with adhesive. If an overcorrection is noted at the first dressing, the long ends of the sutures are pulled downward to offset in part the operative effect. A Frost lower lid suture to elevate the lower lid completes the operation. A ptosis

dressing may be applied as well. Figures 294 to 296 are the essential steps in the technique of this operation. Figure 297 illustrates a congenital unilateral ptosis corrected by this technique (the lid folds are quite pronounced), and a case of acquired unilateral ptosis before and after correction.

FIG. 298.—Partial ptosis from windshield cut with correction by reattachment of sectioned portion of levator. *A*, prior to surgery, *B*, after surgery.

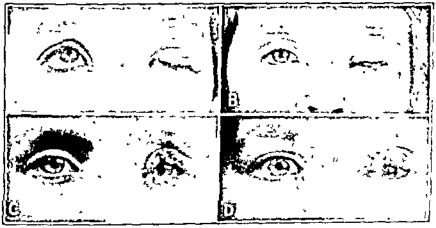


FIG. 299.—*A*, prior to removal of neurofibroma, *B*, after the plexiform neurofibroma was corrected, *C*, lid notching following levator reattachment, and *D* upper lid immediately after cartilage implant.

Occasionally, following trauma wherein the levator has been sectioned, but is still with an adequate nerve supply, the ptosis present can be corrected by resection of the scar and an external route dissection to release the sectioned and retracted levator and to reattach it by means of the technique quite similar to that just outlined. This is especially applicable in those forms of ptosis wherein a part of the lid is still functioning. Figure 298 illustrates this beautifully. An additional complication occasionally arises with levator advancement following plexiform neurofibromatosis. Figure 299 illustrates such a case. In this, the tarsal plate was resected

of necessity at the time the plexiform neurofibroma was originally removed. Some time later, the ptosis was corrected according to that technique just mentioned, wherein the levator was released and reattached. The pull upon the lid margin from the reattached levator now unopposed, because of the absence of the tarsal plate, resulted in a very unsatisfactory and unsightly notching at the lid margin. Full correction was obtained by the use of a plate of cartilage from the concha inserted beneath the orbicularis, the orbicularis fibers being closed over it. Figure 299, *D*, illustrates the satisfactory support to the lid margin which was obtained as a result of this procedure. The technique was referred to in the consideration of marginal defects.

De Lapersonne,[1] Angelucci,[2] and Greening,[3] separately, though each in a rather similar manner, presented personal experiences and individual operations for the correction of ptosis by advancement of the levator. Greening's was a modification of DeGrandemont's.[4] This had been Galezowski's modification of Bowman's. Bowman's before that had been done upon the suggestion of and with the advice of von Graefe. De Grandemont's technique, in the final analysis, is not dissimilar from that practiced by Everbusch. De Lapersonne's and Angelucci's are an augmentation of this last technique. The others all antedated the technique of Everbusch and hence need no further consideration herein.

Angelucci not only shortened the levator tendon through a similar sectioning and suturing, but at the same time utilized the action of the occipitofrontalis. The black silk sutures which are used to join the cut end of the muscle to the anterior surface of the tarsus are tied at their point of insertion, and then passed upward between the orbicularis and the tarsal-orbital-fascia to emerge 3 mm. above the eyebrow. There they are tied in bow knots over small gauze bolsters or through perforated rubber plates. These sutures can be opened from day to day and retied slightly tighter in each instance. The author has utilized this and in each instance, but one, the sutures steadily sloughed through the tissues as they were tightened from day to day and were wholly removed within three weeks. A nice cicatricial tract remained. In one instance, the sutures did not come out within this time; their ends were therefore cut short above the eyebrow, allowed to retract under the skin surface, and were permitted to remain there permanently without causing distress of any kind.

The correction of trachomatous ptosis is essentially an advancement of the levator with shortening of the levator muscle. Wheeler's technique for tarsus resection will take care of the major number of cases of trachomatous ptosis. The resection of the tarsal plate with the removal of the accompanying cul-de-sac achieves the result desired very nicely. It hardly seems necessary to proceed with a complete Blaskovics technique in these instances. Most ophthalmologists, however, have seen trachomatous ptosis of such a degree that one might seriously consider the advisability of a classical Blaskovics procedure. It is impossible to make a hard and fast rule. Certainly, the resection of the tarsal plate and the adherent deformed conjunctiva is a valuable part of the operation.

[1] Arch. d'ophth., 23, 497, 1903.
[2] Thirteenth Internat. Cong. of Med., Paris, 1900
[3] New York Eye and Ear Infirmary Reports, 1904.
[4] New York Eye and Ear Infirmary Reports, 1904.

Busacca[1] has combined the operations of Snellen, of Anagnostakis, of Hotz, and of Chronis, combining them to obtain a correction with a curved lid margin and a free elevation from the cornea. The technique is not difficult, and is as follows. It should be quite satisfactory for old trachomatous ptosis.

An incision is made parallel to the upper lid margin and 5 mm. above it. The skin is pushed up, and the whole muscle between the orbital septum and the tarsus incised. Fibers of the orbicularis muscle are drawn down to the free border of the lid margin so that the surface of the tarsus is partly free. The muscle is then freed from the lower lip. The muscle is undermined, grasped with two forceps and excised. Five to 8 mm. from its lower edge the tarsus is incised, but care is taken not to go too deep. Small wedges of the tarsus below the line of incision and above the line of the ciliæ are removed. Thus, the tarsus is made as thin as possible. A real step is secured between the thin lower and the thick upper part. Five sutures are inserted, taking in the lower wound lip and the upper step of the tarsus. The upper skin margin is left alone to enable it to form the natural skin fold. The sutures are tied loosely for the cosmetic effect and to avoid overcorrection. The threads are fixed to the skin of the forehead. A bandage is applied and not removed for forty-eight hours.

The sutures are then cut 0.5 cm. from the knots. After forty-eight hours more all sutures are removed. Treatment with ointments is continued until the wound has healed (usually after the fourth or sixth day).

If one perforates the skin while separating it from the orbicularis muscle, no harm is done; a few sutures can take care of it. Sometimes the bulbs of the cilia are damaged and fall out, but they usually return. Perforation of the conjunctiva does not interfere with the result and requires no suturing.

In cases of severe blepharophimosis, this operation is not sufficient. Then Busacca does a canthoplasty a few weeks later. Sometimes a recurrence of the trachomatous process in the cornea is observed immediately after the operation. The author believes that this is due to the trauma. These recurrences are not severe. In very young patients there is a tendency, after the operation, for the upper lid to drop over the lower lid if the eye is closed forcibly. This also disappears uneventfully and ultimately.

THE UTILIZATION OF THE OCCIPITO-FRONTALIS

The replacement of the levator by the action of the occipito-frontalis has been responsible for the greatest number of ptosis operations. The simplest form of utilizing this technique is by the use of various buried sutures. Roberts' technique, while perhaps the most complicated, is certainly the most directly applied of all, in that it actually uses the occipito-frontalis fibers. Hess, de Wecker, Dransart, Snellen and Wilder recommended a combination operation wherein sutures were utilized plus open dissection. Kirschner and Lexner presented such operations, and more lately Wiener[2] also, who discussed and gave his modification of Lexner's original procedures; as did Dickey with his combination of a superior rectus fascia

[1] Ztschr. f. Augenh., 88, 100, January, 1936.

[2] Arch. Ophth., 57, 597, 1928, and Clinical Congress Am. Coll. Surg., San Francisco, October 28, 1935.

lata sling. Finally, we have to consider the attachment of the lid to the occipito-frontalis by means of one or more epithelial flaps according to the techniques of Panas,[1] of Machek, and of Hunt-Tansley; this last was devised by Hunt and later modified by Tansley. The Roberts operation was antedated considerably by a very similar technique recommended by Freeland Fergus.[2] Both of these were undoubtedly inspired by an early Vautrin-Derier procedure for utilizing directly the occipito-frontalis fibers.

Pagenstecher's sutures are two or three double-armed threads of waxed braided black silk which pass under the skin from the free border of the eyelid upward to above the eyebrow. There they are tied over a gauze roll. The sutures are left in place for a period of two to four weeks or until cicatricial bands have formed at their site. Koster buried these sutures under the skin to remain there permanently, though Bishop and Mules also utilized permanently buried sutures; but Mules recommended gold or silver wire while Bishop substituted for the wire a fine woven chain of gold. The author has repeatedly used two permanent buried white silk sutures placed through an open incision in the upper lid orbito-palpebral fold, reforming this fold, placed according to Wilder's technique, to complete in a very satisfactory manner an earlier inadequate autoplastic correction. In these days of aseptic surgery, the use of such buried sutures has decreased decidedly, for in the absence of suppuration, cicatricial bands do not usually form.

De Wecker modified Pagenstecher's sutures by the removal of skin and underlying muscle. Snellen's sutures and procedure are rather similar to the resection of Everbusch and Angelucci. Instead, however, of carrying his sutures out above the eyebrow he brought one end of each suture through the lower skin incision margin, while the opposite end of the suture is passed upwards between the orbicularis and the orbito-palpebral fascia to the level of the eyebrow, returned the same way, then to an exit for this end through the skin at the upper lip of the lid incision. In this way when the sutures are tied the skin incision is closed, the shortened levator is advanced and at the same time considerable occipito-frontalis pull is utilized.

Dransart proceeded quite similarly; he, however, employed buried absorbable sutures. Further, his original technique did not resect any portion of the lid. It was really a simple folding of the orbicularis and levator fascia through a skin incision. Wilder's[3] operation was rather similar to Dransart's in that he used absorbable sutures passing these into the tarsus one on either side of its center. Each pair of needles is then carried upward a few millimeters apart, in their upward course, however, instead of traversing the orbicularis as do Dransart's, they are quilted through the tarsal orbital fascia and brought out so as to include the muscle and connective tissue beneath the upper lid of the brow incision.[4] The sutures are drawn up to the degree desired for the elevation of the lid and tied. In this way there are not only two cicatricial cords formed connecting the tarsus and occipito-frontalis, but also an actual shortening of the septum orbitale is achieved. Mules and Bishop have rather similar procedures but that of Wilder is the best.

[1] Gifford, S. R., Arch. Ophth., October, 1932

[2] Brit. Med. Jour., 1901.

[3] Ann. Ophth., vol. 7, 1898.

[4] Beard's Ophth. Surg., P. Blakiston's Son & Co., p. 234, 1914.

Hess' operation is ideal for all the instances wherein sutures are utilized. The operation is not to be used unless there is a full and free contraction of the occipito-frontalis muscles. In other instances the results of operation are *nil* after a few months. Local block and infiltration anesthesia are usually sufficient. Figure 300 illustrates the technique of the operation. After the eyebrow has been shaven, a horizontal incision is made above the skin of the eyebrow parallel to and of a length equal to the palpebral fissure. The incision should go through the skin alone and not include the deeper structures. Bleeding will occur rather readily if the deeper structures are incised. The upper lip of this incision is not undermined; the lower of the two, however, is undermined downward along the anterior surface of the tarsal plate to the free border of the lid. Three mattress sutures are then placed as in the Pagenstecher-Wilder technique. The first lies in the center of the lid and two others equidistant to the sides. Each is to be double-armed with a rather long half-curved needle. They are first passed through the skin 5 to 6 mm. from the hair line in a slightly curved manner,

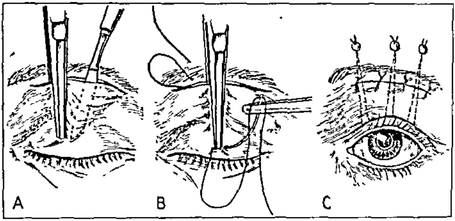


FIG. 300 —Hess ptosis operation

that is, the middle one to be 5 to 6 mm. from the hair line while the two outer ones would be 4 to 6 mm. All six needles emerge between the lips of the wound. The lips of the wound are then spread and a superficial bite is taken with each needle through the orbicularis 3 mm. below the level of the fixed upper lip of the wound. The two central needles should lie perpendicularly above the skin insertion; the four lateral needles, however, should diverge slightly, in pairs, the outer toward the temple and the inner toward the median line; also it is wise to have the innermost suture diverge even a bit more from the perpendicular than the outermost pair of needles. The needles are then passed upward behind the upper lip of the wound close to the periosteum and are brought out through the skin surface about 2 cm. from the incision. The points of emergence for each pair of needles are to be rather close together. These are now tied through perforated rubber plates or through pearl buttons. In this way the lid is raised, the skin insertion of the needles forms a fold in the skin, and the orbicularis bite, which was taken by each needle before the sutures were passed under the skin of the forehead, quilts the orbicularis and at the same time holds

lata sling. Finally, we have to consider the attachment of the lid to the occipito-frontalis by means of one or more epithelial flaps according to the techniques of Panas,[1] of Machek, and of Hunt-Tansley; this last was devised by Hunt and later modified by Tansley. The Roberts operation was antedated considerably by a very similar technique recommended by Freeland Fergus.[2] Both of these were undoubtedly inspired by an early Vautrin-Derier procedure for utilizing directly the occipito-frontalis fibers.

Pagenstecher's sutures are two or three double-armed threads of waxed braided black silk which pass under the skin from the free border of the eyelid upward to above the eyebrow. There they are tied over a gauze roll. The sutures are left in place for a period of two to four weeks or until cicatricial bands have formed at their site. Koster buried these sutures under the skin to remain there permanently, though Bishop and Mules also utilized permanently buried sutures; but Mules recommended gold or silver wire while Bishop substituted for the wire a fine woven chain of gold. The author has repeatedly used two permanent buried white silk sutures placed through an open incision in the upper lid orbito-palpebral fold, reforming this fold, placed according to Wilder's technique, to complete in a very satisfactory manner an earlier inadequate autoplastic correction. In these days of aseptic surgery, the use of such buried sutures has decreased decidedly, for in the absence of suppuration, cicatricial bands do not usually form.

De Wecker modified Pagenstecher's sutures by the removal of skin and underlying muscle. Snellen's sutures and procedure are rather similar to the resection of Everbusch and Angelucci. Instead, however, of carrying his sutures out above the eyebrow he brought one end of each suture through the lower skin incision margin, while the opposite end of the suture is passed upwards between the orbicularis and the orbito-palpebral fascia to the level of the eyebrow, returned the same way, then to an exit for this end through the skin at the upper lip of the lid incision. In this way when the sutures are tied the skin incision is closed, the shortened levator is advanced and at the same time considerable occipito-frontalis pull is utilized.

Dransart proceeded quite similarly; he, however, employed buried absorbable sutures. Further, his original technique did not resect any portion of the lid. It was really a simple folding of the orbicularis and levator fascia through a skin incision. Wilder's[3] operation was rather similar to Dransart's in that he used absorbable sutures passing these into the tarsus one on either side of its center. Each pair of needles is then carried upward a few millimeters apart, in their upward course, however, instead of traversing the orbicularis as do Dransart's, they are quilted through the tarsal orbital fascia and brought out so as to include the muscle and connective tissue beneath the upper lid of the brow incision.[4] The sutures are drawn up to the degree desired for the elevation of the lid and tied. In this way there are not only two cicatricial cords formed connecting the tarsus and occipito-frontalis, but also an actual shortening of the septum orbitale is achieved. Mules and Bishop have rather similar procedures but that of Wilder is the best.

[1] Gifford, S. R., Arch. Ophth., October, 1932.
[2] Brit. Med Jour., 1901.
[3] Ann. Ophth., vol 7, 1898.
[4] Beard's Ophth. Surg., P. Blakiston's Son & Co., p. 234, 1914.

the orbito-palpebral fold in proper position. The author feels that this bite in the orbicularis is rather essential. The sutures should not be tied too tightly or they will cut through the tissues so soon that there will be insufficient time for the formation of the necessary permanent cicatricial bands. The immediate end-result should present a lagophthalmos so great that with the eyes straight to the front the lid margin is at a level with or even above the upper limbus. A Frost suture, into the lower lid, with or without the classical ptosis dressing, completes the operation. It is wise to do the first dressing forty-eight hours after the operation and daily thereafter. The sutures should remain in place from two to three weeks, at this time they usually can be readily removed. Overcorrection does not occur. In a great many cases the results are good. As Beard said, "occasionally the results are excellent and rarely unsatisfactory." Figure 301 illustrates the results of a Hess ptosis operation on the left eye in acquired unilateral ptosis. In this operation there was no buried orbicularis bite. The results are satisfactory, but there is no lid folding.

A *B*

FIG 301.—Illustrative case for Hess ptosis operation shown in Figure 300 *A*, before, and *B*, after Unilateral ptosis, paralytic, old syphilitic. Note contraction of the occipito-frontalis; end result of the Hess operation. The elevation of the lid is maintained only by the action of the occipito-frontalis (Courtesy of Jour. Am Med Assn)

The author feels, however, that the Hess operation has its most ideal application in the correction of traumatic ptosis, as seen after blepharoplasties, and with cicatrices.

Figure 183 is such an illustration. The case is one of socket reconstruction and upper lid reconstruction following traumatism, the ptosis remaining being ideally corrected by means of the Hess procedure. In this instance the orbicularis fibers, which were still intact, were not sufficient to permit adequate anchorage to the occipito-frontalis. Either the Hess procedure had to be used or a fascia sling. Because of the cicatrices present consequent to the reconstruction of the lid, it was thought wisest to use the Hess technique. The presence of such scars and the possible presence of inadequate orbicularis fibers are the two important considerations in this as in all similar cases.

Panas[1] is the originator of a valuable method for the correction of ptosis.

[1] Maladies des Yeux, T. XI, p. 140 1894.

It applies especially to bilateral and unilateral ptosis in children, it is of value in the correction of cicatricial ptosis, and is valuable in the correction of acquired ptosis in adults from an incomplete third nerve palsy. Its basic principles furnish the only method available for the correction of ptosis following neurofibromatosis. As Panas states, "it is a correct autoplastic fixation of the lid to the occipital frontalis muscle by means of a skin flap." He speaks of the operation as blepharopexy. The two more recent modifications of his operation are the Machek and the Hunt-Tansley procedures.

There is but little difference between the original Panas technique and the more recent Hunt-Tansley technique except that in the latter the autoplastic flap of skin used for lid elevation is considerably narrower and passes through a tunnel well above the eyebrow rather than below or into the eyebrow.

The original Panas operation lifted a broad tongue of skin from the lid surface. A horizontal incision is made mid-way between the eyebrow and the free border of the upper lid, through the skin and the orbicularis fibers down to the tarso-orbital fascia. From this incision two others are made, one on each side and through the skin only vertically downward, or even inclining slightly outward. At the ends of the tarsal plate each is made even more divergent, so that in terminating, the incisions are almost parallel with the ends of the first incision. The flap thus outlined by the three incisions is dissected free. A cut is then made along the mid-line of the entire shaven eyebrow, through the skin and the thick layer of muscular fibers formed by the interlacing of the orbicularis and the frontalis. The bridge of skin between the two horizontal incisions is tunneled with a scalpel; the flap overlying the tarsus is pushed up through this tunnel, and then firmly sutured to the superior lip of the upper incision by three stitches. Superficial sutures as necessary are used to close the wounds.

The degree of effect needed is regulated by placing the primary incision higher or lower, as the case may be, and by the extent to which the buried flap is drawn up. If it is observed, in drawing up the flap, that there is a tendency to ectropion before the sutures are tied, two other sutures are placed into the tarsal-orbital fascia, one on either side of the middle flap, but not into the skin. These also are passed through the tunnel and are united to the upper lip of the brow incision near its extremities. They are supposed to lift the paralyzed lid in a natural manner, that is, by giving to it the movement of a rotary hinge, upward and backward, revolving on an imaginary axis, which passes through the two commissures.

The procedure, while successful to a degree, has certain serious drawbacks. The considerable disturbances of the normal relation of the parts, the obliteration of the physiological sulcus, and the substitution for it of an inverted fold, the covering up of an epithelial surface by a raw one, and the fact that the effect, after all, is obtained by what amounts to a pronounced resection of the skin (even though occipito-frontalis action is utilized), are all objectionable features.

The Hunt-Tansley operation minimizes several of the drawbacks just mentioned. A physiological fold of the lid is retained and the buried epithelial tongue is not as extensive, though there is no doubt that much of the correction obtained is through a skin resection, plus the utilization of the occipito-frontalis. This is the one outstanding drawback to the

procedure. The cicatrices from the operation disappear after a certain length of time.

Two vertical parallel incisions are made through the skin, 4 to 6 mm. in width, starting from the mid-line of the lid 4 to 6 mm. above the line of lashes and continued upward to just below the level of the shaven eyebrow. On each side of these vertical incisions, other incisions are made from their base, parallel to and at the same distance throughout, from the lid margin. The canthal ends of these last incisions are joined to the earlier vertical incisions by slightly curved cuts thus outlining 2 triangular areas of skin. These two triangles of skin are removed leaving the orbicularis and the tarsus exposed (the original technique included the removal of the orbicularis within these incisions). The author does not do this; in fact, he feels

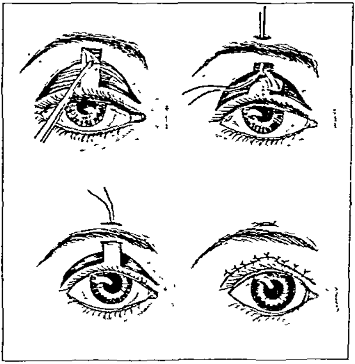


FIG. 302.—Hunt-Tansley technique.

rather strongly that it should not be done. Figure 302 is a sketch showing the technique of the surgery. As soon as the two triangles have been removed, the upper extremity of the tongue of skin is lifted and a double-armed No. 1 braided suture is mattressed through it at its upper extremity. Using these two sutures as traction sutures this tongue of skin is freed by sharp dissection, from the underlying orbicularis, down to the lid margin. It will facilitate the resection of the triangles and the dissection of this flap if a lid spoon is placed beneath the lid. The tongue of skin is then held taut and its anterior epithelium surface vigorously scraped with the sharp edge of the scalpel; the scalpel being held perpendicular or vertical to the skin surface so that this cannot be inadvertently cut. This scraping is continued until the superficial epithelial layer has been thoroughly traumatized (a modification of the original technique). This can be

checked by carefully observing the superficial bleeding present on the surface of the tongue of skin. S. Gifford[1] stated that his father, H. Gifford, early recommended the use of trichloracetic acid on this skin tongue liquifying the superficial epithelium which can then be much more readily removed with the edge of a scalpel and the excess acid neutralized with dilute alkaline solution. It is quite *necessary to remove this stratified epithelium before bearing the flap; otherwise, fistulization from subsequent* desquamation will certainly occur. A stab wound is then made from above in the mid-line, above the position of the eyebrow, along the surface of the periosteum, emerging beneath the surface of the eyebrow at that point from which the upper extremity of the tongue of skin was resected. A small hook is passed through this tunnel, the sutures grasped, drawn through the tunnel, and the tongue of skin drawn up thereafter. This should have been cut of such a length that it can be withdrawn from the upper opening of this tunnel for at least 2 mm. While it is held in that position, sutures are passed from the anterior lip of this opening through the tongue of skin

A B

FIG. 303 —Illustrative case for Hunt-Tansley technique shown in Figure 302 *A*, before, and *B*, after. Unilateral congenital ptosis; and the same case eighteen months later Notice the facial expression which is now normal, the action of the superior recti being satisfactory. (Courtesy of Jour. Am Med. Assn)

to the posterior lip of the opening and then tied. Two of these should be used, one on each edge of the tongue of skin or at each extremity of the stab wound. *Care should be taken in drawing the slip of skin through this* tunnel that it is not twisted upon itself. The skin edges in the lid are closed with fine black silk sutures. It is especially important that sutures pass from the lower incision lying in the lip of the lid wound to the base of the tongue of skin. These should lie in the same line as do the other sutures closing the skin at those places from which the triangles had been resected. In some instances it will be difficult to achieve this result. In general, however, if one is particular in estimating the length of the skin tongue necessary for full correction, *then it will be possible to have this lower* incision line, from the stab wound, with its sutures, approximate rather closely the line of skin closure. If the tongue of skin is too long, it will simply protrude through the upper extremity of the stab wound and this part will be wasted. Further, if the stab wound is made too high, it will *be difficult to obtain* satisfactory closure. Figure 303 shows a case of

[1] Personal communication.

unilateral congenital ptosis corrected at the age of one year, and a photograph of the child two years later. See Figure 277, *C*, for a still later view of this patient.

The Machek ptosis operation has been used several times by the author, and it is a rather satisfactory procedure. The Giffords have recommended it as being especially adapted for complete ptosis particularly where the levator and the superior rectus muscles are paralyzed. It is essentially a utilization of the Panas principle except that two narrow strips of skin are formed to elevate the lid instead of one broad flap or even one narrow tongue as with the Hunt-Tansley system. The modification of the Giffords is essentially as follows: "An incision is made 3 mm. above the lid margin and parallel to it, the incision being carried to within 3 mm. of the inner and outer angles. A second incision is made parallel to the first and 4 mm. above it. This is carried slightly beyond the extremities of the first for a few millimeters. The skin between these two incisions is divided vertically in the middle of the lid and the two halves freed by sharp dissection up to their attached bases. The epithelium of the skin is removed by trichloracetic acid and by scraping with a scalpel. Double-armed sutures of waxed, No. 1 braided silk are mattressed into the free extremity of each of the two flaps. Two short incisions are made above and parallel to the eyebrow and at the inner and outer ends of the brow, close to the periosteum, as is recommended in the Hunt-Tansley. Blunt scissors are introduced into these incisions and tunnels formed under the skin down to the base of each skin flap. The sutures and their flaps are drawn through these tunnels and there anchored to the skin at the stab wounds. The sutures should be tied over pearl buttons to prevent their cutting through the skin. The amount of traction made on the sutures is variable depending upon the amount of elevation necessary. The postoperative treatment is the same as for any other ptosis operation. Gifford[1] in his article called attention to an air-tight shield dressing which he uses for his ptosis cases so that moisture will condense upon the under surface of the shield and thus prevent drying of the cornea. Figure 304 illustrates the technique.

The use of fascia lata has been recommended repeatedly by several men in the plastic correction of ptosis. Bexer reported in 1923 an operation in which fascia was to be used for this, his principal recommendation being the satisfactory reëstablishment of an upper tarsal fold. It was a modification of Kirshner's original method wherein a broad strip of fascia alone was used. Bexer in his operation used two narrow strips of fascia lata, his dissection and the placing of the strip of fascia was very much like that followed out in the Machek ptosis operation except that he utilizes this fascia and not the skin. A skin incision is made and the two narrow strips of fascia sutured into the occipito-frontalis muscle immediately beneath the brow. Derby modified this operation by utilizing a single strip of fascia lata anchored in the mid-line of the lid to the anterior surface of the fascia and tarsal plate in a V-formation so that the two ends of the strip of fascia could be widely diverged and attached to the occipito-frontalis above the site of the eyebrow near the inner and outer extremities of the eyebrow.

The fascia lata hammock of Derby[2] has as its original technique the following:

[1] Arch. Ophth., vol. 8, October, 1932.
[2] Am. Jour. Ophth., Ser. 3, vol. 11, May, 1928

(1) An incision is made through the skin down to the tarsus, along the edge of the lid just above the lashes. The upper lip of the skin is dissected back far enough to allow the hammock of the fascia lata to fit in under it and be covered. (2) As in the Machek operation two tunnels are made under the skin to points somewhat above the eyebrow. This is best done with a double-edged sharply pointed knife. (3) A piece of fascia lata approximately 7 to 9 cm. long and 1 cm wide is then secured. A mosquito clamp has already been passed downward through each lid tunnel. (4) An end of the fascia lata is then placed in each clamp and the fascia is drawn up into position. (5) With a full-curved needle the fascia on the one side is sutured with one or more deep stitches of silk or catgut to the frontalis as close to the periosteum as possible. The fascia lata hammock is then pulled tight by the loose end and that is then sutured to the frontalis in a similar way. One or two small skin stitches may be necessary.

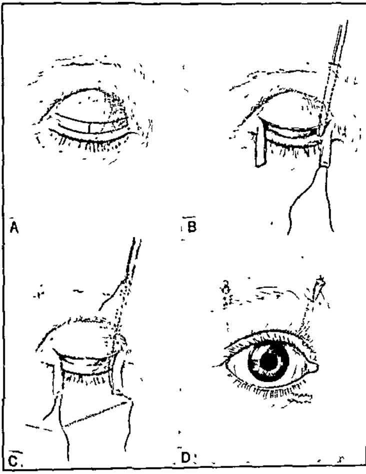


FIG. 304.—Technique of the Machek operation. (Gifford)

Reese, in his fascia operation formed two tongues of orbital, pretarsal fascia and orbicularis fibers, joined together by a common base in the mid-line of the lid; and these sutured through diverging tunnels toward the eyebrow, as with the Machek principle. Figures 305–310.

Wiener[1] recommended the operation for paralytic ptosis wherein an abnormal superior rectus is also present. Figure 312 illustrates his tech-

[1] Surg., Gynec. and Obst., February, 1934.

nique. An incision is made in the skin in the middle of the upper lid exposing the tarsus and cleaning it of orbicularis. Two incisions are made above the eyebrow one at either end, down to the occipito-frontalis. A Reverdin needle is passed from one opening over the brow down under the skin to the opening in the lid. One end of the fascial strip, previously prepared,

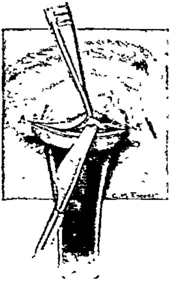


Fig. 305

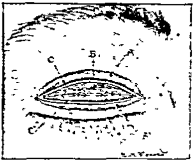


Fig. 306

Fig. 305.—*AA′*, line of incision through the skin only. Dotted line shows amount of dissection of skin from subcutaneous tissue.[1]

Fig. 306.—*AA′*, everted skin. *B*, crescentic area composed of subcutaneous cellular tissue and a portion of the orbicularis. Dotted line shows position of primary incision through the skin.

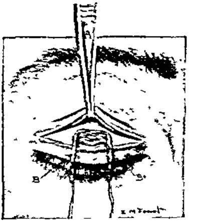


Fig. 307

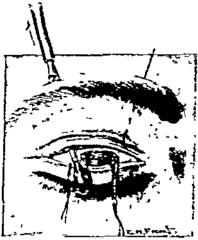


Fig. 308

Fig. 307.—*A*, forceps holding up the dissected area of skin and subcutaneous tissue from the convex border of the tarsus and tarso-orbital fascia; *BB′*, the two lateral flaps dissected from the tarsus. Sutures passed through their distal ends; *C′*, 10 mm. of tissue in its normal attachment to the middle of the tarsus.

Fig. 308.—Entrance of the double-edged knife, and its emergence at the external side of the 10 mm. attached tissue with the thread from the external flap in the fenestra. The arrow shows the entrance, direction and emergence of the knife on the internal side.

[1] Figures 305–310, Reese, courtesy of Arch. Ophth., 1924.

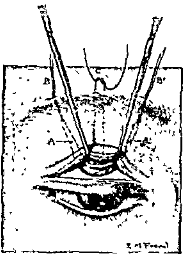


Fig 309

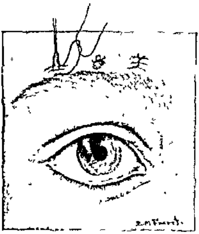


Fig 310

Fig. 309 —*AA'*, flaps lying on the tarso-orbital fascia, *BB'*, flap sutures emerging through the openings above the brow; *C*, anchor suture with its loop on anterior face of attached tarsal tissue, and its emergence above the crest of the brow

Fig. 310 —Entrance of suture through the opening of skin and flap.

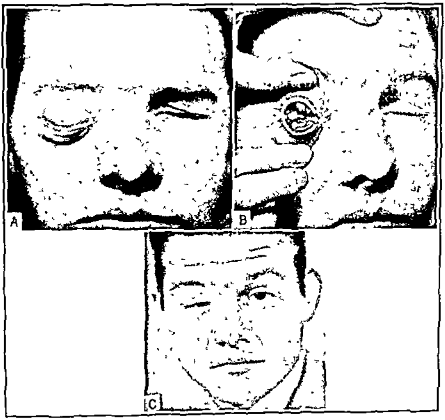


Fig 311.—Complete rupture of the levator palpebri superioris (See text for details of reparative surgery). *C*, following Reese operation for ptosis.

is drawn up and the end is sewn to the occipito-frontalis tendon. The Reverdin needle is then passed from the other incisions above the eyebrow to the lid opening; the strip of fascia is drawn up, a hook having been first slipped through the loop of the fascia to determine by upward traction where to anchor the strip under the brow. This strip is then fastened to the tarsus by two buried silk sutures. The three skin incisions are closed with fine black silk sutures and the operation completed with a Frost, inferior lid suture and with a ptosis dressing.

Figure 311 illustrates beautifully the advantages of the Reese type of technique. *A* and *B* illustrate the case after the initial repair of the traumatism, that is laceration with complete detachment of the upper and lower lids, laceration through and through into both cul-de-sacs, rupture

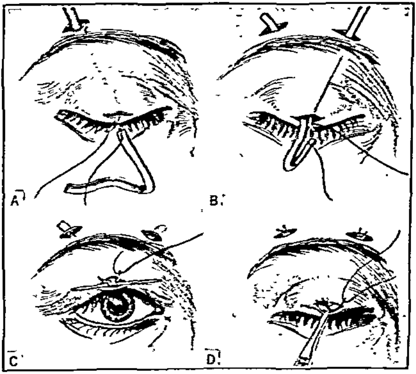


FIG 312.—Wiener's fascia sling for ptosis.

of the internal canthus, traumatic paralysis of the inferior, internal and superior recti, and, naturally, the destruction of the levator. Plastic surgery involved was the resection of the cicatrix as one sees at present in these two illustrations, readjustment of the conjunctiva into the cul-de-sac, and resuture. The levator paralysis, that is the complete ptosis was then corrected by the orbicularis transplant (see *C*). The visual acuity present in the eye was 6 9. The opposite eye had been lost through an earlier accident. Figure 313 is a case of ptosis following neurofibromatosis in whom, with an earlier Hess technique considerable of the ptosis recurred. *A* is before and *B* after a fascia sling correction—suture line as seen ten days after surgery and at the time of discharge from the hospital.

The direct utilization of occipito-frontalis fibers was first recommended

by Freeland Fergus in 1901. In 1916, Roberts, of Philadelphia,[1] presented an operation for ptosis which continues this system quite satisfactorily. The eyebrow is shaven and an incision carried from the root of the nose along the superciliary ridge almost to the external angle of the frontal bone. From the nasal extremity of this cut a vertical incision is made through the tissues of the forehead almost to the hair line. The flap formed is turned upward and outward so as to expose the occipito-frontalis muscle. An incision just beneath the upper orbital margin is carried down to the fascia of the upper lid from the nasal to the temporal side, following the curve of the bone. This skin flap is turned downward, the tarsal plate exposed and its upper edge identified. A tunnel is then cut beneath the soft tissues about

FIG. 313 —Old ptosis, thick upper lid, considerable scar. (See text, following (a) fascia sling) Observe the good orbito palpebral fold Patient at time of discharge from hospital, upper photo prior to surgery, lower photo, sutures removed, some postoperative edema, position of right eyebrow shaven, vision 6/22

$\frac{1}{4}$ inch in width extending from this, under the orbicular muscle, to the incision made through the shaved eyebrow. From the muscular belly of the occipito-frontalis muscle, immediately above the tunnel opening, a strip of muscle fibers is outlined about 8 to 10 mm. wide and 20 to 25 mm. long. The parallel incisions are made diverging a little at the upper end so as to make the muscular tongue wider near its upper extremity. A cross incision is made at its upper end converting the muscular strip into a long flap still attached by its lower end. This flap is turned downwards, thrust through the tunnel and attached to the upper edge of the tarsal plate by three fine silk sutures. The two corner sutures are placed as mattress

[1] Ophthalmic Record, XXV, N S, pp 397-402, 1916.

stitches and hold the flap on top of, that is superficially to, the tarsal-fibrous plate. Returning to the frontal region, two strips are cut, one on each side of the defect for the turned down flap, each half the width of the inverted flap, having its only attachment to the muscle above. These are drawn together toward the root of the inverted flap, attached to it on the superficial surface (which formerly had been the under surface), by a mattress suture at each edge, and then they are united in the mid-line by a third suture, also placed as a mattress suture.

FIG 314.—Roberts' technique for the direct utilization of occipito-frontalis muscle (Courtesy of P Blakiston's Son & Co)

"An additional suture is inserted at one edge where the first flap was bent over, to keep it thus folded. (Fig. 314.) The superficial skin flap of the forehead is then replaced and sutured in position by catgut, by silk, or by a dermol subcuticular suture. In addition to the patient's ability to raise the eyelid, the operation makes a normal and satisfactory furrow in the lid at the seat of the upper edge of the tarsal plate. If both upper lids are to be corrected the same vertical forehead incision can be used, either immediately or reopened at some later date.

"If the incision through the eyebrow to that at the middle line of the forehead for any reason seems undesirable, the flap can be turned outward and downward instead of outward and upward by making the horizontal incision within the hair line of the scalp instead of in the eyebrow. It probably makes very little difference which incision is made, unless the superciliary one employed in this instance should interfere too much with the branches of the supra-orbital nerves and vessels. These will be less disturbed if the horizontal cut is made at the top of the forehead through the hair instead of at the bottom through the eyebrow." The disadvantages to this operation are evident at a glance —the first is, it is rather difficult, and the second is the amount of forehead scarring. Of course, neither of these is insurmountable, and, in patients very early in life the operation is to be seriously considered, especially for the severe cases. The author has used it with full satisfaction.

THE UTILIZATION OF THE SUPERIOR RECTUS

The last and one of the most satisfactory procedures for the correction of ptosis consists of the utilization of the superior rectus. The procedure depends upon the recommendation made by Parinaud in 1897.[1] A year later Motais[2] first presented his technique according to these recommendations of Parinaud Haab, in 1904,[3] recommended the operation very highly, but he called attention to the fact that Cannas recommended the procedure even before Parinaud and Motais. The original technique has been modified and simplified several times to great advantage. Considering the fact that the effect and value of the operation depends upon the

[1] Ann d'ocult., 127, 12, 1897

[2] Bull et mém. de la Soc. d'ophth. de Paris, November, 1898.

[3] Augen Operationslehre, von O Haab, München. Verlag von Lehmann, Bd. 31, p. 318, 1904

synergy of action which exists normally between the superior rectus and the levator palpebræ superioris, it stands to reason that the operation cannot be used in the absence of good superior rectus action. Further, an equally reasonable original premise is that of Shoemaker,[1] to the effect that, even though Motais claimed to supply a perfect physiological substitute for the levator by such a transplantation of the superior rectus tendon, this is not actually the case. "The lid after the Motais operation is held in its new position by anchorage to a fixed point on the eyeball, so that there can be no elevation or movement of the lid through the transplanted portion of the superior rectus independent of the eyeball." If this is the case (and the author concurs in it), then the simplest form of secure attachment of the upper lid to the superior rectus is the proper surgery for the case. Figures 284 and 285 show the normal intimate relationship which is present between the superior rectus muscle and the levator tendon; and if the illustration is carefully examined, the rationale of the surgery is plainly seen. There are two qualifications, however: the operation does not lend itself to unilateral ptosis; and second, the presence of a normal superior rectus, with normal action, is absolutely essential.

The various modifications of the Motais are considerable in number. The author wishes to call special attention to Shoemaker's modification of the original Motais and to Wilder's further modification of Shoemaker's technique. Kirby[2] has continued in the simplification of the technique. Greeves[3] has modified it further by a tarsal plate plastic, and Dickey[4] has combined superior rectus surgery with a blepharopexy by means of a fascia lata sling. Wiener has combined an advancement of the levator with Motais's principle by inserting the paralyzed levator into the intact tendon of the superior rectus. The author utilizes the Motais principle whenever it is possible, all dissection being done through the upper lid (as recommended first by Shoemaker) and without opening into the conjunctival cul-de-sac at any time. There are many other modifications of the utilization of the Motais principle but those which are to be described are characteristic—additional text would be superfluous.

Figure 315 is a copy of the original illustrations of Motais. They are clear and need no great additional description. The operation is best done under general anesthesia but cocain instillations and a cocain-adrenalin injection can be used for local anesthesia. The eyeball is rotated downward with a stout suture placed through the conjunctiva close to the upper limbus, and while the upper lid is held everted, a T-shaped incision is made in the conjunctiva above the limbus and into the conjunctiva overlying the tarsal cartilage. The edges of this incision are undermined and the tendon of the superior rectus is exposed. The middle third of the tendon is separated from the remaining portion of the tendon by a small scalpel, the sharp blade of the scissors, or with a small sharp hook. A slip of tendon is thus formed about 3 mm. wide and 1 cm. long. A double-armed suture is placed in this, at its intact scleral insertion, the sutures being passed from beneath the slip upward. This tongue is then cut free from the sclera and held to the side by small forceps. An incision with a small scalpel is then

[1] Ann. Ophth., October, 1907.
[2] A Modified Operation for Blepharoptosis, Arch. Ophth., 57, 4, 1928.
[3] Brit. Jour. Ophth., 17, 741, December, 1933.
[4] Am. Jour. Ophth., Ser. 3, 19, 660, August, 1936.

to be made through the levator muscle, in the upper extremity of the vertical line of the T-incision at the upper border of the tarsal plate and parallel to this upper border. Curved scissors are passed through this incision and carried to the anterior surface of the tarsal plate, the points then directed toward the lid margin, separating the skin from the underlying tissue to a point 3 to 4 mm. from the line of cilia. The two ends of the suture are then passed through the levator incision and through the tunnel of skin formed upon the anterior surface of the tarsal plate, to emerge through the skin 4 mm. from the lid margin. The conjunctival wound is now closed, the sutures tied over a roll of gauze or through a pearl button, and the usual ptosis dressing applied.

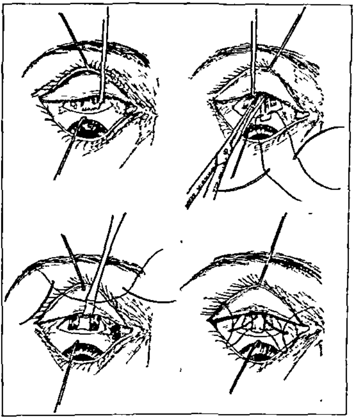


FIG 315 —The classical Motais technique (After Haab, Augen Operationslehre, Verlag, Lehmanns, München, 1904, and Jour Am. Med Assn)

The usual postoperative technique follows in so far as the after-treatment is concerned. The author has observed in many of these cases, immediately postoperative, after Motais surgery (regardless of its modification), that the patient has a rather definite disinclination to look down. It is strongly recommended that the patient be compelled to do this several times, at each dressing, to prevent undesired adhesions.

In Shoemaker's modification (Fig. 316) he passes the double-armed suture through the tendon slip of muscle from above downward, placing the loop on the upper surface of the slip. The orbicularis fibers are then undermined, exposing the tarsus on its upper margin. To do this, a hori-

zontal incision is made through the skin of the lid and the orbicularis down to the upper margin of the tarsus. The lid is now buttonholed, and Shoemaker carries the sutures through this opening to fasten the tendon directly to the surface and the edge of the tarsus precisely as is the tendon of any muscle attached to the sclera in advancement surgery. Each needle is passed through the tarsus and then out through the skin and tied there over a roll of gauze. Wilder (Fig. 317) added to Shoemaker's modification the insertion of two absorbable sutures in the ligament of the tarsus on either side of the buttonhole through which the muscle slip has been passed, thereby shortening or tucking the tendon of the levator palpebræ superioris.

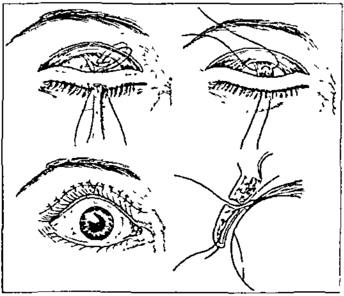


Fig. 316.—The Kirby and Shoemaker modifications, showing also diagrammatic cross-section of the lid section. (Courtesy of Jour. Am Med Assn)

Kirby's technique[1] *is as follows:*

A horizontal incision 25 mm. long is made through the skin and orbicularis to the tarsus, 8 mm. above the eyelid margin. The aponeurosis of the levator is followed backward to 8 mm. above the tarsal border. Here a horizontal incision is made through the levator and tissues of the upper eyelid, exposing Tenon's capsule The conjunctiva of the fornix is held down out of the way by a traction suture An opening is made in Tenon's capsule at the temporal side of the superior rectus and a hook is slipped beneath the muscle. The latter is exposed so that a tongue of muscle and tendon 4 mm. wide by 10 mm. long can be fashioned. A double-armed silk suture is passed through 2 mm. from its end. The muscle slip is transferred to a pouch which is prepared for it anterior to the tarsus. The needles are passed downward, piercing the eyelid margin, just nasal to the center of the cornea, and the suture tied, drawing the muscle tongue and lifting the eyelid to a position of correction. A second suture is used to support the first and to secure accurate and firm apposition to the tarsus. The levator is not necessarily united The skin incision is closed by interrupted sutures. Excess tissue may be resected. A protective dressing must be applied. The sutures are removed after seven to nine days.

Figures 318, 319, and 320 show respectively a patient operated according to the original technique, one case operated by the Shoemaker technique, and one showing the combined Shoemaker-Wilder technique.

[1] Personal communication.

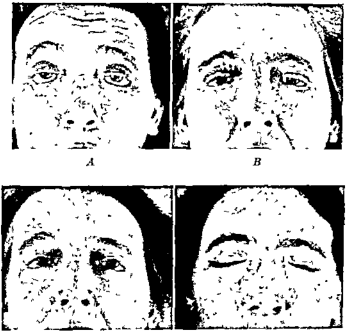
Wiener's combination of levator attachment to the intact tendon[1] is most clever. The tarsus is exposed by an incision across the center of the upper lid near the upper border of the tarsus and the main portion of the

A *B*

Fig. 318.—*A*, before, and *B*, after operation by the classical Motais technique, *Francis W Shine's case*

A *B*

Fig 319.—Hunter W. Scarlett's case *A*, with lids closed, and *B*, with lids open (Shoemaker technique.)



A *B*

C *D*

Fig. 320.—Bilateral congenital ptosis Note marked occipito-frontalis correction in attempt to lift the upper lids *ad maximum*; *B*, immediate end-results with some edema of the lids still present; sutures still in place; *C*, same case six months later (notice loss of all occipito-frontalis contraction); *D*, same case to illustrate lid closure possible.

[1] Presented at Clinical Conference, Am. Acad Ophth. and Oto-Laryngology, 1937.

levator near the tarsus exposed between two hooks. Two sutures are then placed close to its insertion into the tarsus. The levator is then cut free from its tarsal attachment and the sutures lifted. A pocket is made with a straight blunt scissors through the fascia of the levator at least 15 mm. above the upper border of the tarsus and through the conjunctiva into the upper cul-de-sac. A speculum is then introduced into the palpebral fissure and the conjunctiva dissected down to expose the superior rectus tendon. The two sutures on the levator are brought down through this dissection and one attached to each side of the superior rectus tendon 5 mm. back of its insertion. Both conjunctiva and skin incisions are closed and the postoperative treatment carried out as is customary for ptosis surgery. Here also, as in all ptosis operations, the Frost lower lid suture is recommended as a postoperative procedure.

The author's technique of the Motais-Shoemaker operation is a relatively simple procedure. A horizontal incision is made through the lid above the upper border of the tarsal cartilage. This is carried through the orbicularis and through the levator and the smooth muscle of the lid down to the eyeball. A stout suture must be passed through the conjunctiva above the limbus to keep the eyeball rotated strongly downwards. A self-retaining speculum is placed in this incision and the superior rectus tendon isolated and lifted from the sclera. A double-armed suture is then passed through the tendon and the muscle fibers of the superior rectus, with its loop on the under surface of the muscle, at the junction of the middle and outer, and middle and inner thirds. This may be whip-stitched. The position of this suture in the tendon is all important. If it is placed too close to its scleral insertion, very little if any correction will be obtained, and if it is placed too far back, an over correction will result. To estimate the correctness of the insertion, the suture above the limbus should be relaxed sufficiently to hold the eye straight to the front. The upper border of the tarsal cartilage should then be grasped and moved to the point on the superior rectus muscle at which the suture has been inserted. The position of the lid margin now will be an estimation of adequate or of incomplete correction. The correction will be sufficient if, at this time, the lid margin just clears the superior limbus of the cornea. This amount of lid elevation would be an overcorrection if it remained unchanged. Subsequent healing, however, results in some later loss of the elevation obtained. The position of the lid margin, therefore, as just described, is the proper one. If the suture is not correctly placed, it should be withdrawn and replaced until the operator is satisfied as to its position in the tendon or the tendinous muscle fibers of the superior rectus. The anterior surface of the upper border of the tarsal cartilage is now bared of orbicularis and of fascia by careful dissection. The two sutures are then passed through the upper edge of the tarsal cartilage at points very slightly wider than that distance in which they lie in the muscle. The two sutures then pass over the edge of the tarsal plate, a second bite taken on the anterior surface of the tarsal plate by each needle about 3 mm. from the upper edge of the tarsal plate and then directly out through the skin above the lid margin. Before these are tied they are again pulled taut and an estimation made of the amount of elevation achieved. If the correction is satisfactory these sutures are threaded through a small pearl button and firmly tied. Two additional absorbable sutures of No. 6-0 catgut are placed from levator fascia at the

upper lip of the incision to the side of the rectus muscle and then continued from there to the anterior surface of the tarsal plate somewhat below its upper border. One is placed on each edge of the muscle and firmly tied, and the ends cut short to be subsequently buried. The skin incision is closed with an intra-dermic dermol suture, a running suture, or with interrupted silk sutures. A Frost lower lid suture completes the operation. Figure 317, *A*, shows the dissection through the lid surface and the suture placed in the superior rectus muscle; *B*, illustrates the continuation of this suture through the upper margin of the tarsal plate and through its anterior surface to emerge upon the skin of the lid; in *b* and *b′*, are also shown the absorbable sutures which pass from levator and levator fascia through the muscle and on to the anterior surface of the tarsal plate, as additional safeguards; and *C*, is the end-result diagrammatically shown. The technique is that of Shoemaker's very slightly modified, utilizing in addition Wilder's adjunct sutures as he first placed them in his Motais technique.

Dickey's superior rectus fascia lata sling is undoubtedly the firmest attachment that one can obtain between the superior rectus muscle and the tarsus. In addition to this, it also, with Shoemaker's modification of the Motais operation, obviates the dangers connected with failures from the classical ptosis operation through tearing of the tendon slip or through sloughing of the sutures in the tendon slip postoperatively. Dickey first obtains an 8 to 10 cm. long strip of fascia lata 5 to 6 mm. wide. (The technique of this has been already given, page 256.) The central third of the tendon of the superior rectus muscle is isolated, but not cut, and a suture looped through it. The fascia lata strip folded once longitudinally (to give added strength) is then passed under the central third of the tendon of the superior rectus and the suture is withdrawn. The conjunctiva and Tenon's capsule over the lateral portions of the muscle are sutured with No. 4-0 catgut, leaving the central portion exposed. The speculum is removed and a horizontal incision 1.5 to 2 cm. in length is made in the upper eyelid, parallel to the lid margin and about 8 mm. from its edge. The incision is extended down to the tarsus and the dissection is continued toward the lid margin and laterally until the tarsus has been exposed sufficiently to allow ample space for the placing of sutures. The upper border of the tarsus then is exposed, and at the middle point just above this edge an incision 5 mm. in width is made through the fascia and tendon into the conjunctival sac. The fascia lata strips are brought through this opening by forceps and pulled down over the tarsus. A double-armed white silk mattress suture is placed in the tarsus at the junction of the outer and middle thirds and well down toward the lid margin. This suture is then passed through the folded fascia lata strip, is tied, and the suture cut. Another double-armed white silk mattress suture is placed in a similar position at the junction of the inner and middle thirds of the tarsus. By traction on the fascia sling the point is determined where the second suture should be placed through the fascia lata. One knot is tied, and if, after inspection, the position of the lid is satisfactory, the second knot is tied. The position of the lid may be varied by lengthening or shortening the fascial sling to lift the lid margin to the edge of the limbus. A second pair of mattress sutures is passed through the tarsus and fascia lata to insure a firm attachment. The excess fascia lata then is cut off close to the second suture. The skin incision is closed with a continuous subcuticular suture.

Dickey calls attention to the rather marked edema which occurs not infrequently in these cases postoperatively. Figure 321 shows the three important steps in his surgery.

Gifford[1] has recently modified the Dickey operation enhancing the value of the procedure to a very definite degree. As Gifford said, functionally and cosmetically the results are much better than formerly obtained. The shape of the fissure after the surgery approximates the normal elliptical one, and the lidfold is usually quite satisfactory. The surgery is done wholly through the upper lid, and Gifford emphasizes the advisability of always using fresh fascia. It should be an ideal procedure for severe

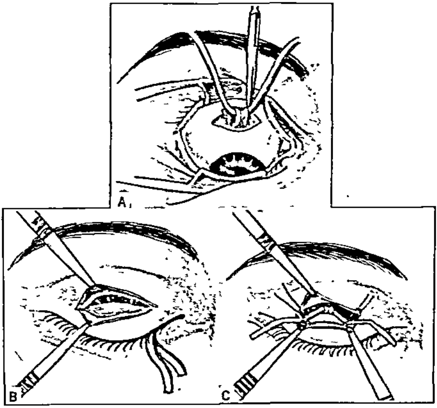


FIG 321.—Technique for Dickey's fascia lata levator superior rectus sling. *A*, dissection of the superior rectus muscle; *B*, incision through lid into the superior fornix, subconjunctivally; *C*, utilization of the fascia.

bilateral ptosis with intact superior recti and probably for children who are a bit younger than those one would select for the classical Motais technique.

Mention must be made of Trainor's technique as well. Wiener feels that it is the easiest to perform and one of the best for ptosis. The lid is everted and a through-and-through right angle incision made through the conjunctiva and the superior margin of the tarsus so that the mid-point of this flap outlined lies at the mid-line of the lid. The vertical incision is to be 2 mm. long, and the horizontal line about 8 mm. in length. An incision

[1] Modification of the Dickey Operation for Ptosis, Arch. Ophth., vol. 28, No. 5, November, 1942.

is then made through the bulbar conjunctiva and the two edges of the superior rectus bared. A mattress suture is placed in the movable angle of the tarsus-conjunctival flap formed, this suture passed beneath the superior rectus muscle, and by means of the suture the tarsus-conjunctival flap is drawn beneath the rectus muscle. The cut edges of the tarsus-conjunctival flaps are then resutured to their former positions—anchoring in this way, the upper margin of the tarsus firmly to the superior rectus muscle. The writer objects to the cul-de-sac adhesion which is formed in that it may limit downward rotation of the eyeball, and cause irritation to the patient. Wiener stated that there may be some initial entropion present but that this disappears very promptly.

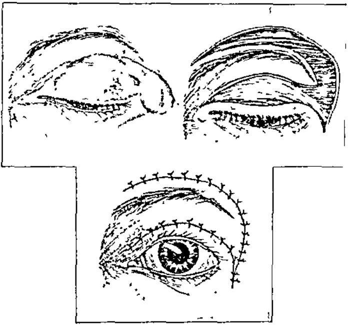


Fig. 322 —Skin resection for the ptosis of neurofibromatosis (Courtesy of Jour Am Med Assn)

Jameson[1] recently published an operation, wherein he lifted an unsectioned loop of the full width of the superior rectus muscle and buries this into a pocket formed for it by slitting into the tarsus near its upper border. The operation is done altogether from the conjunctival side. The superior rectus is exposed and two double-armed silk sutures introduced through the rectus from below; these sutures are then passed through the slit made in the tarsus carrying the muscle up with them—to be tied upon the skin surface. Jameson states that graduations in the degree of correction can be obtained with his operation in four ways: by introducing sutures at varying distances from the insertion of the muscle (the farther back these are introduced the greater the gradation); by folding the muscle on itself in drawing it into the pocket; by lowering the aperture of the pocket on the tarsus; and last, by approximating the end of the muscle (loop) by traction nearer the intermarginal space.

[1] Arch Ophth., vol 18, October, 1937.

A *B*

FIG. 323 —Ptosis from and with chronic follicular conjunctivitis, right eye, probably trachomatous *A* before and *B*, after tarsus resections, Wheeler technique. (Jour. Am. Med Assn., vol 109 December 4, 1937.)

FIG. 324.—Ptosis with neurofibromatosis. Cartilage graft was used, in addition, to elevate the eyeball (Jour Am Med Assn, vol 109, December 4, 1937.)

FIG 325.—Ptosis with neurofibromatosis, with the loss of the zygoma. Final operation was a fascia sling (Jour. Am. Med. Assn., vol. 109, December 4, 1937.)

Ptosis, when accompanied by other oculomotor paralysis, is not essentially different in so far as therapy is concerned. The oculomotor condition must be corrected first, however, to guard against diplopia following the correction of ptosis. Figure 145 illustrates the correction obtained by a levator advancement in a complete third nerve paralysis case with strabismus fixus and amblyopia in the deviating eye. In a given case, such surgery may consist of: (1) tenotomy of the inferior oblique; (2) advancement of the inferior rectus; (3) advancement of an internal rectus and advancement with resection of a superior rectus; last, an advancement of the levator with tarsectomy. The head tilting, the only residual sign, from the original, may remain after surgery is completed. Even though many of these cases are corrected for purely cosmetic reasons, the sequence of the surgical procedures must be as outlined. (See section on the correction of paralytic strabismus, pp. 222, etc.)

Complicated ptosis, as with benign neoplasms, is best illustrated by those not rare cases of neurofibromatosis with ptosis. Some of these cases have other extensive defects accompanying, as the loss of the zygomatic process, marked deformity of the floor of the orbit, etc. After tumor resection (for roentgen-ray is absolutely valueless in these conditions), the skin and orbicularis must be resected as in Figure 322. The major number of cases can be completed with a Hunt-Tansley procedure with fair satisfaction. Figures 324 and 325 illustrate two such instances.

Acquired Ptosis

Earlier in this section an incidence and etiological table for congenital ptosis was presented.[1] That portion considered only congenital situations as these apply to the levator, to the accompanying extra-ocular muscles in *addition to the levator which may be involved, and had also considered* other congenital defects as colobomata, epicanthus, ankyloblepharon, and microphthalmia which have as an accompaniment a congenital ptosis not due always to levator paralysis alone.

This section is to consider only acquired ptosis, not developmental defects; ptosis as the result of traumatisms, or of disease.

It is a fact that most cases of acquired ptosis are surgical problems Some of these are of this type very early in their course as, for instance, a complete sectioning of the third nerve. In others, the surgical correction is to be carried out at a considerably later date as in the pseudo-Graefe syndrome or ptosis following a head injury. A small percentage of the cases never become surgical situations; progressive external ophthalmoplegia, the ptosis of myasthenia gravis, and the ptosis of thyrotoxicoxis (at times) are such situations.

Classification:

1. Traumatic (peripheral, cicatricial).
   - Figure 311 is a peripheral traumatic ptosis from pure cicatrix with complete destruction of the levator by evulsion of the levator.
   - Figure 298 is a peripheral type of ptosis from a partial sectioning of the levator.
   - Figure 290 is a peripheral type of ptosis as a result of cicatrices in the superior conjunctival cul-de-sac apparently from trachoma.

[1] Trans. Am. Acad Ophth. and Otolaryn , 1942.

Classification:—(*Continued.*)

2. Traumatic (central and cerebrospinal) essentially sympathetic nerve paralysis.
3. Third nerve paralysis.
   (*a*) Peripheral.
   See Figure 153 the result of section of the third nerve by an intra-orbital knife wound.
   (*b*) Infra-nuclear (trunk).
   See Figure 144. This is the type of injury which is commonly responsible for the pseudo-Graefe syndrome.
   (*c*) Nuclear.
   See Figure 287, a case of progressive external ophthalmoplegia with complete bilateral ptosis.
   (1) Vascular (brain stem hæmorrhage; ophthalmoplegic migraine). Syphilitic amyotrophy.
   See Figure 326, *A*, a case of ophthalmoplegic migraine as reported by Bruce and Wilson.[1]
   (2) Direct trauma, indirect trauma, as from a basal lesion.
   (3) Inflammatory.
   See Figure 326, *B*, ptosis of a case of cerebellar ataxia, inflammatory and degenerative situation wherein ptosis is not uncommonly a symptom. (Bruce and Wilson.)
4. Third nerve regenerating fibers (pseudo-Graefe syndrome). See Figure 144.
5. Cervical sympathetic paralysis.
   A classical cervical sympathetic paralysis as seen in cervical sympathetic resections or paralysis. See Figure 327, *B*.
6. Atonic ptosis (senility, old enucleation).
   Figure 101 is a rather classical atonic ptosis following an old enucleation.
7. Neuromuscular.
   See Figure 321, a case of:
   (*a*) Myasthenia gravis.
   (*b*) Thyrotoxicosis.
8. Degenerative. Blepharochalasis.
   See Figure 216.
9. Neoplasm, as neurofibromatosis.
   See Figure 324.
10. Hysterical.
   See Figure 328, *A* and *B*.

Traumatic, peripheral, which includes conjunctival conditions such as trachoma and pemphigus, epidermal defects from contracting cicatrices and socket and lid defects are seen often.

Traumatic, central, is very closely allied with third nerve paralysis as seen in subdivision three above. It is included, however, as a portion of traumatic acquired ptosis because of its etiology. It is a consideration of such a situation as occurring from head injuries, chiasmal, and cavernous sinus pathology, and neoplasm and inflammatory situations.

Third nerve paralysis: Third nerve paralyses are to be subdivided into

[1] Wilson and Bruce, Neurology, Williams & Wilkins Company, Baltimore, 2, 1352, 1940.

peripheral, infra-nuclear, and nuclear. Under peripheral are such intra-orbital situations as one would see from nasal accessory sinus pathology. The cavernous sinus syndrome and the syndrome of sphenoidal ridge meningioma would be examples of neural factors. Third would be the pure trunk involvements as one sees not uncommonly in fractures at the base.

FIG. 326, A.—Ptosis with ophthalmoplegic migraine Paroxysmal periodical ptosis. (From Wilson and Bruce, Neurology, courtesy of Williams & Wilkins)

FIG. 326, B.—Ptosis with cerebellar ataxia. (Other forms of ophthalmoplegia less common.) (From Wilson and Bruce, Neurology; courtesy of Williams & Wilkins)

The infra-ocular situations are those conditions as temporal lobe neoplasm, sphenoidal-temporal lobe abscess, multiple sclerosis, and/or similar posterior longitudinal bundle situations, and complete third nerve internal and external ophthalmoplegia.

The nuclear situations to be considered are the vascular brain stem hæmorrhages, ophthalmoplegic migraine, aneurysms (saccular and otherwise), inflammatory conditions and cerebellar abscess.

The ptosis of third nerve *regeneration*, that is the pseudo-Graefe syn-

drome, has been discussed. Cervical sympathetic paralysis and the ptosis of atony are pure surgical problems and appear under that subdivision. Myasthenia gravis and thyrotoxicosis are seldom if ever surgical situations. The ptosis of blepharochalasis is a clean-cut surgical problem and is considered in another division. The surgery of neurofibromatosis and its resulting ptosis is discussed under that subdivision.

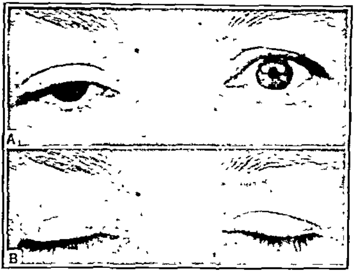


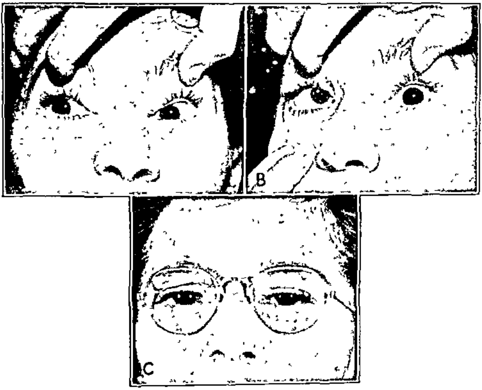
Fig 327 *A*.

Fig. 327 *B*.

Fig 327 *A* —Ptosis with and from myasthenia gravis.
Fig. 327 *B* —Ptosis with and from cervical sympathetic paralysis. Case one of bilateral cervical sympathetic resertion with stripping of the carotid plexus

Group 10, hysterical ptosis, is rather rare. Figures 328 *A* and *B* are such an instance. The patient, aged eighteen years, developed the condition following a relatively minor head traumatism. Neurological examination was negative throughout. During the recovery stage of a general anæsthesia (given for that purpose only) the patient demonstrated normal ocular motility and normal lid action, bilateral. Figure 328*A*, *A* is an unposed photograph in repose; *B* is taken with patient looking directly at the camera; *C* illustrates the lack of response on the part of the patient, for she is attempting to follow a moving finger. Figure 329*B*, *A* is taken

A



B

FIG. 228.—Post-traumatic ptosis of hysteria (see text).

with manual elevation of the ptotic lids without instructions to the patient; *B*, patient is instructed to look to the left. It illustrates the limitation of upper rotations in the left eye with a suggestion of overaction of the right inferior oblique muscle. *C* is the patient in repose, eyes to the front, both lids normally lifted but wearing a crutch to lift the right upper lid alone. Releasing the lid from support on this side is followed immediately by bilateral ptosis.

FIG. 329.—Ptosis dressing universal postoperative regardless of type of ptosis operation which has been done. Frost lower lid suture to protect the cornea. Photograph taken on fourth postoperative day at the time of second dressing. In this instance, operation was bilateral levator advancement. Motais procedure and the Hess type of surgery would not need the buttons as placed here for the sutures.

Surgical Principles for the Correction of Acquired Ptosis.—In discussing, in general, the surgical principles for acquired ptosis one must, of necessity be rather indefinite as to details. Many cases of acquired ptosis have characteristics which are so definitely individual to the case being studied that principles alone are possible.

Group 1: In this, scar resections are essentially of outstanding necessity. Following this the Hess technique is to be used if orbicularis fibers are not sufficiently normal for an orbicularis transplant. Actually it is probably the ideal situation for the Hess procedure. Orbicularis transplants and fascia lata slings, however, are probably equally satisfactory.

Groups 2 and 3: These conditions are essentially paralytic regardless of the site of the pathology at fault, hence orbicularis transplants and fascia slings are the technique best indicated.

Group 4: In this the first procedure is to resect the levator from the tarsus and the superior cul-de-sac, including a resection of the lateral horns of the levator. Sometime later an orbicularis transplant, as outlined by the Reese technique, is the operation of choice. There should be an interval between the two operations so the surgeon can be assured that a complete

paralytic ptosis has replaced the earlier pseudo-Graefe syndrome. When ptosis from cerebral sympathetic paralysis becomes an operable situation levator advancement is sufficient for the correction. In many of these cases it is not necessary to resect the tarsus simultaneously.

Groups 5, 6 and 8 and subsections, are a matter for levator resections. Usually, however, through the external surface because in many of these cases there is destruction of orbicularis fibers and atrophy of the levator. Some of them have a shallow inferior cul-de-sac, and a large atropic fundus of the orbit may be present in others. The ptosis which accompanies blepharochalasis is corrected nicely by the surgery necessary for the primary condition. In some of these instances, especially in those cases wherein the pathology is due to an old long-standing enucleation, a Tenon's capsule implant may be a first operation of necessity. Following this the inferior cul-se-sac, formerly shallow and now perhaps lost, must be replaced with a skin graft, the third procedure then is the correction of the ptosis, preferably by the Everbusch technique.

Group 7: Neuromuscular ptosis is not a surgical situation.

Group 9: The surgery of neurofibromatosis following the resection of the tumor is largely and in almost all instances a matter of utilizing the Hess procedure. Because of the scars present and secondary to earlier surgery no other form of procedure is possible except the use of fascia lata.

Group 10: Hysterical ptosis is not a surgical situation.

CHAPTER XII

SURGICAL CONDITIONS OF THE LIDS—CONTINUED

ECTROPION. TRICHIASIS. ENTROPION. CUL-DE-SAC RECONSTRUCTION. PEMPHIGUS (ESSENTIAL ATROPHY OF THE CONJUNCTIVA)

ECTROPION and trichiasis and entropion are to be considered together from a surgical standpoint. The latter two are simply degrees of the same deformity.

ECTROPION

Ectropion may affect both the upper and the lower lids, and will range from a complete loss of the skin of the lid with the presentation of the entire conjunctival cul-de-sac, to a very slight deformity of the lid margin. The condition is often present in old people due to a senile relaxation of the skin and muscles of the lower lid. With the exception of a few post-operative forms, which will be mentioned later, herein, the condition is practically always an accompaniment of trauma or of chronic ocular disease. Under this there are two types seen, a scar tissue contraction ectropion and a paralytic or relaxation ectropion. The latter is present in the lower lid only and corresponds to the ptosis present in the upper lid.

Correction is demanded in an ectropion because of the constant epiphora, the keratitis, and the conjunctivitis from the exposure of these tissues, and because of the unsightly defect. Ectropion may also complicate contracted sockets following enucleations, whether operative or traumatic.

Ectropion may be further subdivided, for convenience, into: spastic, atonic, and cicatricial forms. A fourth form of ectropion is occasionally present, but it is so definitely mechanical, due to exophthalmos, to staphylomata, to retrobulbar inflammatory changes, and to similar evident and potentially more serious circumstances, that it can be dismissed with this mention. The correction of the underlying condition is necessary for the correction of this accompanying ectropion.

Spastic and atonic ectropion are quite different. Spastic ectropion is usually an accompaniment of acute orbital inflammation. It almost seems as if the retrobulbar inflammatory process is pushing forward against an irritated hypertonic orbicularis. As a result of this the tarsal plate is abruptly everted. When this is once established, further irritation and swelling continue the process. Beard speaks of the condition as blepharoparaphimosis. Atonic ectropion, which is usually confined to the lower lid, is due to a paralysis of the orbicularis combined with an atonic relaxation usually of all of the tissues of the lower lid. As a result, there is an actual increase in the length of the lower lid.

The senile or atonic forms of ectropion are readily corrected. Those of mild degree will usually respond to a series of galvano-cautery punctures after the method of Ziegler. With this procedure a series of cautery punctures are made within the conjunctiva of the inferior cul-de-sac, 3 to 4 mm. behind the lid margin, and a slightly less distance from each other. The punctures should pass into the tarsal plate but not through it. The slight amount of cicatricial tissue formed in the inner surface of the tarsus

will tend to invert the ectropic lid margin. Figure 330, *A* and *B*, shows the results from this.

Paralytic or senile ectropion of the lower lid of the more severe degree will need a tarsorrhaphy or a blepharoplasty at the outer canthus. The old method of Snellen's ligature may be used in cases of moderate degree but the results are not always lasting. In a case for correction, the operation planned depends almost entirely upon the degree of the ectropion; after that the underlying cause is of importance. The operations described should, in the order stated, correct the senile defects from the moderate cases to the severe types.

FIG. 330 —*A*, results from Ziegler cautery puncture for ectropion *B* shows results of this

Figure 331 illustrates the Snellen ectropion and entropion sutures as well as the Gaillard-Arlt sutures. Two double-armed sutures are to be used. Each needle is introduced into the everted conjunctiva at the edge of the tarsus nearest to the margin of the eyelid and to the right and the left of the greatest point of the ectropion. This will usually lie at the junction of the outer and inner thirds of the lid. The needle is passed down through the eyelid to appear on its surface about 2 cm. below the lid margin. Each end of the double-armed suture is passed similarly, but each at about 4 mm. from the other. The two sutures are tied over a roll of gauze with sufficient tension to straighten the lid margin and correct all ectropion. A strip of adhesive may be placed over the tied sutures but the eye need not be bandaged. The sutures may be removed after six days or more, or allowed to remain for six weeks, depending upon the degree of ectropion present and its underlying cause. Several other similar sutures have been recommended, but this one has been satisfactory with the author under all circumstances. Verhoeff has a somewhat different suture from the prin-

ciple of the Snellen suture. It is rather similar to the Axenfeld suture, which has been described for lagophthalmus, in that it is the replacement of atonic orbicularis fibers by looped inelastic braided silk sutures. His suture, however, is retained only from two to three weeks, while the Axenfeld is a permanently retained buried suture. A long and slightly-curved needle is armed with *a No. 2 waxed braided suture. This is passed* immediately beneath the skin, beginning at the outer angle, about 6 mm. to the nasal side of the commissure and about 3 mm. above it. The suture is passed 3 mm. from the lid margin immediately beneath the skin of the lid to a position over the inner angle similar to that at the outer angle. This end is threaded through a pearl button. The needle is then withdrawn, the other end of the suture rethreaded, the suture looped through a pearl button, and a second loop of the suture passed 3 mm. below the upper loop, starting, however, from a point only slightly below the site of the insertion of the first suture. This suture emerges at the outer angle close to the first end. Here the two sutures are passed through the second pearl button, and tied with bow knots and with sufficient tension to evert the lid into slight entropion and to hold it there. A postoperative dressing is not necessary. The sutures are to be tightened or loosened through the temporal button as the occasion demands.

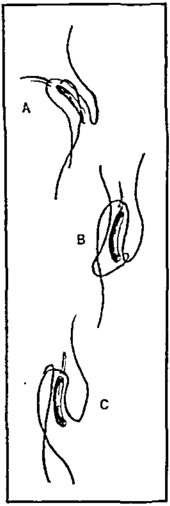


FIG 331 —*A*, Snellen suture for ectropion, *B*, Gaillard-Arlt suture, *C*, Snellen suture for entropion.

Wiener[1] has recommended a strip of fascia lata placed very similarly to those Verhoeff sutures for the ectropion and sagging of the lower lid which results from seventh nerve paralysis. A strip of fascia lata is to be anchored to the internal canthal ligament, passed beneath the lid margin subcutaneously to the outer corner and there sewn tightly, stretched, to the external canthal ligament and to the periosteum of the outer orbital margin. Wiener states: "I believe it will hold the lower lid firmly against the globe and prevent the disagreeable constant flow of tears as well as add to the patient's looks."

The excision of a wedge of conjunctiva and tarsus, apex of the wedge downward, according to the method of Kuhnt, is a very satisfactory form of treatment. *The excision must stay well away from the skin to prevent* an immediate perforation, or by subsequent sloughing, coloboma of the lower lid. The sutures, when placed, should pick up the tarsus and conjunctiva separately, and the suturing must start at the apex, inferior portion of the area of excision. Some redundancy of the skin may result, but it will eventually smooth itself without a defect remaining. This operation brings the cul-de-sac upward toward the eyeball.

[1] ... Third Nerve Paralysis. Arch. Ophth., vol 57, June, 1928.

Imre[1] describes an operation for senile ectropion which he has used with excellent results for the past eight years in numerous cases. An incision 12 to 16 mm. long and 8 to 10 mm. deep is made *in the marginal portion* of the lid in its middle third, extending more nasally than temporally. A second incision parallel to the first and 3 mm. below it is made in the skin. A short vertical incision is made, usually on the temporal side, to connect the two *incisions. A Kuhnt triangular piece is removed from the conjunctiva.* To determine its size, the free skin is drawn temporally to see how much will overlap, and the relaxed conjunctiva then indicates the amount to be removed, usually 6 to 8 mm. A similarly sized triangle *should be removed from the skin below the lower incision. This is made* 3 mm. deeper. The sutures are placed as follows: one near the apex of the conjunctival triangle with the knot in the conjunctival sac; the second suture is brought out through the skin of the intermarginal line, and two *sutures close the skin triangle in a vertical line. The extra skin on the* temporal side can be excised. One or two sutures should be used to repair the temporal angle of the incision.

Kuhnt's operation was the forerunner of many different operations for *triangular resections. Müller was the first to modify this by incising the* lid margin and separating the conjunctival lamella from the underlying orbicularis lamella so that in addition to the conjunctiva triangular resection there could also be a readjustment of these two lamellæ to minimize *that folding* which would occur on the skin surface.

The removal of a triangular area of skin at the outer canthus, apex downward, and base including in part the margin of the lid, will correct the more severe forms. The triangular area of tissue is excised, an intermarginal incision made in the lid margin for a distance the same length of the triangular excisions, and the broadly pedicled flap thus outlined is undermined. In the suturing a start is to be made at the apex of the area excised. The lid flap is moved outwardly by the sutures, thus straightening the line of the *lid* margin. This procedure may be accompanied by a simultaneous excision of the conjunctiva and of the tarsal plate at the middle point of the lid, depending upon the amount of correction demanded Considerable correction can be obtained in a relaxation ectropion by the amount of *the movement allowed to the triangular flap outlined at the* outer canthus. This operation alone, or combined with the first, elevates the level of the lower lid, draws it up toward the outer canthus, and causes the conjunctival surface of the lid to lie in close apposition to the conjunctiva of the eyeball. When *the excision of skin at the outer canthus is* done alone the effects of the operation may be emphasized by the excision of a tiny triangle of conjunctiva and tarsus at the outer canthus as suggested by Elschnig. The conjunctiva is then sutured before the flap of skin. *The apex of this small area will lie on the same plane as the* level of the larger triangle, its apex opposite and naturally deeper in the cul-de-sac

Adam's operation, which was one of the first for through-and-through wedge resection, took care of this in the mid-line of the lid. Von Ammon *moved it to the external canthus. Walther moved it even more* laterally, resecting a triangle from both the upper and the lower lids, as was necessary, the bases of these triangles lying conjointly in the upper and lower lids with the apex lying laterally to the external canthal angle. Argyll-

[1] Klin. Monatsbl. f. Augenh., 95, 303, September, 1935.

Robertson *combined a triangle* resection near the outer canthus with a strap-like pedicle flap lying parallel to the lid margin. This he swung up and out so that the redundant skin was moved laterally without folding. The Szymanowski modification of the Kuhnt operation is, however, the most satisfactory of all of these. Figure 332 illustrates the technique. The entire eyelid margin is split posterior to the line of lashes. A triangular section is then made of conjunctiva and tarsus, at the mid-point and of such a size that when the two edges were approximated the conjunctiva turns in against the eyeball. The triangular conjunctival section should be done first. The Szymanowski resection is then made at the outer canthus, its base directed upward and outward, its length being determined by the

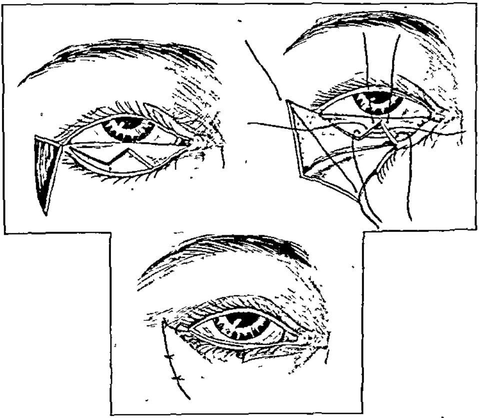


FIG 332 —Kuhnt-Szymanowski technique.

degree of ectropion present. The second incision extends straight downward from this and of twice its length. The third incision connects the lower end of this with the one started in the angle of the outer canthus. The skin is then slightly undermined, and the wounds are sutured. The triangular tarsal wound should be closed first; three fine silk sutures are adequate, the point of the triangle being first closed. These sutures should not be placed too close to the edges of the wound, because they are easily torn from the tarsus. Special care is to be taken in placing the last suture, so the edges of the incision are accurately approximated and the margin of the eyelid well reëstablished. The skin triangle is closed, after removing the lashes on the apex of this. The first suture is to pass from the outer

angle of the defect to the apex of the skin flap. The other sutures should close accurately the remainder of the wound to insure primary union. A third suture is necessary at the center of the eyelid margin where the tarsus resection was done. It should be a fine, double-armed suture, passing from the conjunctival to the skin surface close to the margin. The loop bridges each side of the closed line of the tarsus to pass through the eyelid and to be tied over a small roll of gauze. This is important, and unless done may leave a cicatricial indentation at the center of the eyelid.

As Meller said, the results of the operation are always brilliant if the excised piece has been of sufficient size. It is important that the upward inclination of the first incision line for the skin resection should not be of a greater angle than that which lies between the two vertical incision lines. If so, closure is difficult because the skin of the upper eyelid will be drawn too far over the tarsus, and it is best to have this angle slightly smaller. See Figure 333 for a satisfactory result, lower lid.

FIG 333 —The application of technique of Figure 332

Siklösy's technique which has been previously mentioned, and the Blaskovics modification of this can be used at times. The modification, however, is the essential factor, in that the suturing will certainly result in a puckering of the skin at the lower lip of the wound if a triangle resection is not carried out there. The more vertical incision of the latest modification by Blaskovics allows a scar to be in the least conspicuous position, gives the greatest amount of lift, and when combined with the triangle lying in the upper lid will correct many cases of a moderate degree of atonic ectropion.

Beard's operation for ectropion is something of a combination of Walther's triangular resection plus Arlt's canthoplasty.[1] The technique as he (Beard) gives it is:

To make a canthotomy and extend slightly the skin cut, undermine this below and remove a small triangle of skin containing a few cilia on the lower lip of the canthotomy wound. The outer extremity of the lower tarsus is forced out and grasped with fixation forceps and while skin and conjunctiva are retracted a catgut suture is passed through this from without at a distance from the cut end proportioned to the length of the proposed shortening. *After this the superfluous bit of tarsus*

[1] Beard, Ophthalmic Surgery, P. Blakiston's Son & Co., 1914.

external to this insertion is cut away. A small triangle of skin and muscle, base in, is now cut from the upper lip of the canthotomy wound exposing the external canthal ligament. The suture is passed through this from within and into the tarsus of the upper lid. The suture is tied, the ends cut short and the skin closed with black silk sutures.

Terson has a simplified operation modified from Walther's triangle resection, which corrects beautifully many instances of a moderate degree of senile ectropion. It has not failed the author in any instance in which it was used. The technique is especially applicable to ectropion with a thickened conjunctiva. A triangle of skin and orbicularis, with its base toward the canthal angle, is first cleanly removed. An equal amount of this is to lie at the same level in both the upper and the lower lids. If anything, the major portion of the triangle should be slightly more below the level of the canthal angle than above. The amount which is to be removed is to be estimated by traction upon the external canthal angle. The base should extend from just below the orbito-palpebral fold, above, to slightly below the level of the ectropion, below. A strip of the thickened conjunctiva is to be resected from the lower lid for the length of the lower lid. This should be at least 2 mm. in back of the lid margin but should spare the normal conjunctiva of the fornix. The tarsus should not be incised. The conjunctival defect is closed with three or four black silk sutures and the triangle at the outer canthus then sutured. The first suture is to be placed from the apex of the triangle to the base of the triangle, but the end in the base of the triangle should lie at the junction of the middle and lower thirds. As this suture is tied it pulls up the relaxed skin surface of the lower lid into the apex of the triangle in a V manner, the arms of which continue with the curve of the orbicularis fibers. The rest of the V is closed with an adequate number of black silk sutures. The only defect the operation has is that it does tend to elongate somewhat the palpebral fissure.

Birch-Hirschfeld reports an operation for the cure of senile and spastic ectropion, involving section of the orbicularis. The muscle is cut vertically through the center of the lid. The lateral portion is drawn upward and inward, and the medial portion downward and outward, and sutured in this manner. A crossing of the fibers is thus produced, the arch of the orbicularis muscle from the lid to its tendon shortened, and the width of the muscle layer broadened.

Cantonnet recommends an operation embodying the excision of a wedge-shaped piece from the lower lid at the external canthus for spastic and relaxation ectropion. He speaks of his operation as external decalage of the inferior lid. He removes the external triangular flap and a portion of the free border of the lid at the external angle, and opens the external angle with a horizontal cut not passing the orbital border. His sutures are placed from the fixed portion of the lid, that is, the tarsus, to the fibrous tissue in the external part of the orbital border, and a second more superficial suture in the superior external angle of the cutaneous flap to the terminal fibers at the tarsus. The remainder of the wound is closed with ordinary skin sutures, no conjunctival suture being considered necessary. The originator of the operation claimed several successes in the use of the operation. In placing the two important sutures one must be careful that the lid is held in its proper position to prevent the occurrence of overcor-

rection and a resulting entropion. The author has used it for the lower lid in relaxation ectropion connected with blepharochalasis of the upper lid.

Scar Tissue Contraction Ectropion.—Scar tissue contraction ectropion demands other methods for its correction. In the very slight cases, especially when the scar is small and linear, and lies immediately below or within the lid, it may be resected and the lid resutured, or the incision made and the tension released through the subsequent rearrangement of *the tissues by suturing, as suggested in one of the above operations.* When this is done the line of the excision releasing the tension should be made in a V manner and sutured together to form a Y. At times the scar can be excised in a triangular or diamond-shaped manner, and by the subsequent suturing of the triangle or the diamond in a perpendicular line, the lid margin will be forced upward into inversion, thus correcting the ectropion. This, however, is only a degree of the V-Y practice. When such a triangular excision is made, the base, naturally, is up. It will assist very much in the placing of the sutures if two small linear incisions are made continuous with the base of this triangle for a distance of 3 to 4 mm., bent downward slightly, and then undermined. This is a modification first mentioned by Dieffenbach. This same surgeon also first advanced the wedge excision external tarsorrhaphy just described. Blaskovics recommends in certain moderate cases of cicatricial ectropion, especially after diseases of the lids, an eversion in which the tarsal cartilage is released through a conjunctival incision, at its lower margin and upon its two surfaces and then everted by pushing it upwards and backwards. Occasionally after this operation, Spanyol states, because of shortening of the cul-de-sac, a complete resection of the tarsal plate must be done. When this is necessary, it can be done through the old conjunctival incision line.

Scar tissue contraction ectropion, however, in the majority of cases, *needs more extensive operative measures than the above. There is no* doubt that tissue which is lost must be replaced. Frequently there has been but little tissue lost at the time of the original injury and the subsequent resuturing, but imperfect or careless primary suturing and secondary infection has resulted in a firm cicatrix with the resulting ectropion. The operator must study each case very carefully to determine whether the case can be corrected with scar tissue resection and suturing, or whether a true loss of soft tissue has occurred. Figure 334 illustrates this well. In this instance nothing was necessary in the case except the resection of the scar and resuturing; *B* shows this suture line at the time of the first dressing. Figure 335 illustrates a similar case; in this, however, the cicatrix lies at the inner angle; *C* illustrates the technique, and *D* illustrates the case at the time of the removal of the sutures. This type of case is undoubtedly the simplest form of ectropion correction. Figures 336 and 337 are somewhat more complicated in that they were accompanied by the loss of the eyeball. The technique, as seen in *B*, shows the scar tissue resection necessary. The closure is then accomplished by undermining the various flaps which appear, and moving them into a correcting position. It is essential that the lid margin be supported by the most mobile flap and the one which can be sutured best into a horizontal direction. The closure of this case was readily achieved, the end-result, as seen, is quite satisfactory. These are instances of simple ectropion without the loss of tissue. The surgery in such instances is done upon the drawing board before the

FIG. 334.—*A*, simple scar resection for ectropion; *B* shows the sutures still in position.

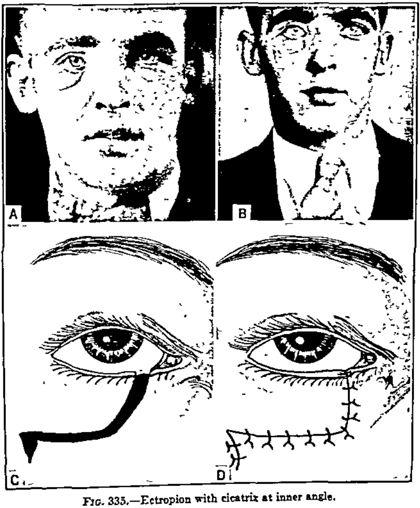


FIG. 335.—Ectropion with cicatrix at inner angle.

patient reaches the operating room. The surgeon should make sketches of his case from photographs, upon these sketches show his scar resection and then decide the direction in which the flaps are to be moved. Another sketch should be made, as in the illustration, *B*, Figure 339, to outline the position of the sutures and the estimated immediate postoperative end-result. This sketch should be taken into the operating room with the surgeon and the plan as outlined carried out. Figure 337 illustrates scar tissue resection and suture in a staggered line to prevent continued contraction. Figure 338, a more complicated case, illustrates this perfectly. It shows the front and side views of a razor fight case as he appeared when

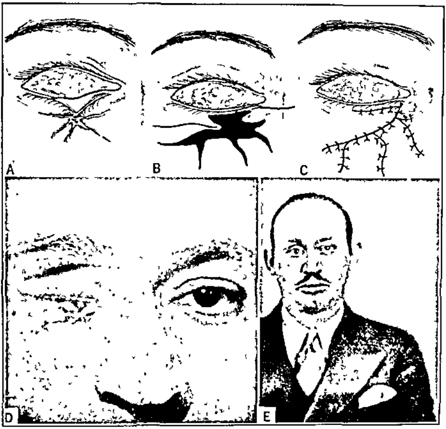


FIG. 336.—Cicatricial ectropion with the loss of the eyeball *A* and *D*, preoperative condition, *B* and *C*, planned resection and suture line, *E*, completed result

first seen. The lower lid has been cut free and lies in a thickened edematous ectropion. The cicatrix in the inner angle shows very plainly the position from which the lower immediate lid inner angle was torn. It is evident there is no loss of tissue. The end-result is seen in *C*. Figure 339, *A*, is a sketch of the original defect made by the author prior to the operation showing the lines of all scar tissue resection; and *C* is the anticipated position of the suture; *C* of Figure 339 is to be compared with the immediate postoperative result of *D* and *E* of Figure 338, which are the photographs taken on the operating table before the case was dressed to show how accurately the plan decided upon could be and was carried out. When the

case is carefully planned (as most of these cases should be planned), the end-results are assured. To repeat, scar tissue resection and suture is applicable *to all instances only where there has been no appreciable loss of soft tissue.*

The same principles apply to those instances so often seen wherein one side of the cicatricial band will be in ectropion and the other in entropion. This is well illustrated in Figure 340. The lateral lip of the wound is inverted while the medial lip is everted; *A* shows the defect present when the patient reported; *B* and *C* are the end-result; *D* a sketch of the original defect, the resection of the cicatrices meticulously carried out; and *F* the

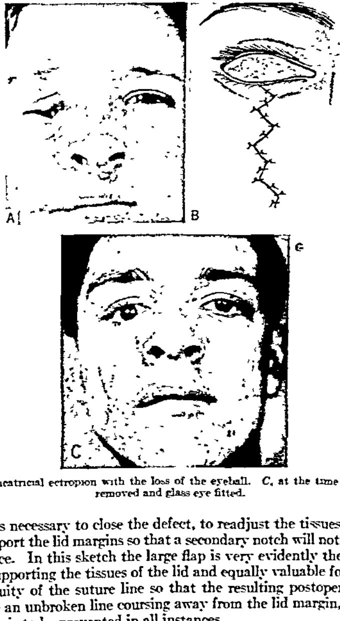


FIG 337.—Cicatricial ectropion with the loss of the eyeball. *C*, at the time sutures were removed and glass eye fitted.

suture lines necessary to close the defect, to readjust the tissues smoothly, and to support the lid margins so that a secondary notch will not be present at any place. In this sketch the large flap is very evidently the one to be used for supporting the tissues of the lid and equally valuable for breaking the continuity of the suture line so that the resulting postoperative scar will not be an unbroken line coursing away from the lid margin, vertically to it. This is to be prevented in all instances.

Loss of soft tissue is an entirely different matter. When this has occurred it must be replaced. Ectropion with this can be corrected either by means

of a pedicle flap or through the use of free skin grafts either dermal, epidermal (that is, full thickness grafts) or the epidermal Ollier-Thiersch grafts.

The blepharoplasty of Fricke and Dieffenbach for this correction is well illustrated in Figure 341. In this case the pedicle flap should be sufficient to correct the ectropion. Correction, which can be obtained without additional scarring, or through the use of flaps, having as their end-results a minimum amount of scar, is of course the best procedure. Flaps are necessary in those cases of ectropion with inadequate conjunctiva or with contracted sockets. Ectropion, in the presence of old osteomyelitis (TB), or of other similar deformities should always be corrected by a pedicle flap, for a free skin graft cannot be placed against an irregular bony surface with success. (See Fig. 69.)

FIG. 338.—Cicatricial ectropion. A and B, preoperative, C, the sutures have been recently removed See legend of Figure 339 for *D* and *E*

Axenfeld describes a hammock flap operation for cicatricial ectropion of the upper lid due to soft tissue loss as an accompaniment of the contracted socket. The flap is cut 5 to 8 mm. below the lower lid margin (naturally this must be in a normal state) with its two pedicles, both of the same width, lying at the level of the normal upper lid margin The flap should be as wide as in the defect in the lid. From the bases of the pedicles short incisions are made to pass over into the canthal angles so that all of the tissues remaining in the upper lid can be elevated from the ectropic lid margin. The flap is then moved into the upper lid into an area formed by the incision and dissection necessary to relieve the ectropion. In some of these cases a deformed tarsal cartilage must be removed before the flap is sutured in place. If the lid margin and the line of lashes are lost, the releasing incision can be made at the conjunctival-epidermal junction so

that the lower edge of the flap will assist in forming the new lid margin; otherwise the incision line should be just above the line of lashes. Three to four weeks later some minor surgery will be necessary to correct a bit of puckering at the canthal angles.

The free skin graft over a mold in the socket can be done if desired at the same time that the flap is placed into the lid. If it is to be done in two stages the flap should be done first, and then as soon as this is healed the socket repair may be proceeded with. Ectropion of the lids following a traumatic enucleation is not uncommon (Fig. 342, *A*). In these cases the deformity

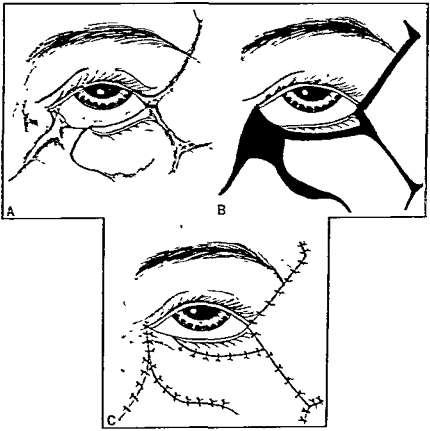


Fig. 339.—Technique for case of Figure 338. The photographs of Figure 338 are to be compared with the preoperative sketches of Figure 339, especially is *C* of Figure 339 to be compared with *C* of Figure 338, in this there is some postoperative edema still present; and also with *D* and *E*.

is connected with a moderately contracted superior cul-de-sac, the downward drag of the cicatrix there forms a deep band with the resulting contrariwise eversion of the tarsal plate of the lower or the upper lids and ectropion. Under ordinary circumstances, permanent intermarginal adhesions are not essential in the correction of a contracted socket. In these instances, however, as just described, they can be used. The superior cul-de-sac is incised and a graft placed into position over a mold, as is customary for the reconstruction of a contracted socket. A large V-apex downward must then be removed from the tarsal plate, either through the posterior surface of the lid or the anterior surface to straighten the deformed carti-

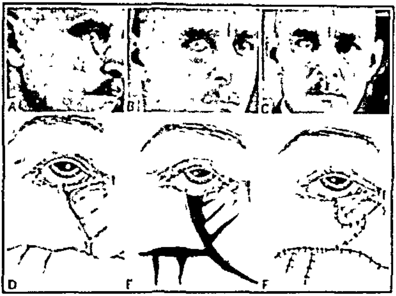


FIG. 340. Combined ectropion and entropion with scar revision correction

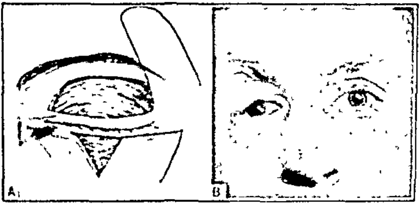


FIG. 341. Classical Fricke's correction for ectropion

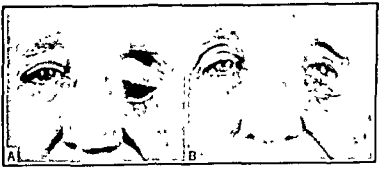


FIG. 342.—*Ectropion with a contracted socket. A*, the defect; *B*, at the time of cutting the adhesions and fitting a prosthesis, four weeks later.

lage, and the operation completed with intermarginal adhesions. In these instances it is wise to use as the mold for the graft a metal conformer rather than a mold of dental stent, in that the conformer is to be retained without disturbing the intermarginal adhesions for at least six weeks. If a mold of stent were retained this long in the ordinary contracted socket, irritation and discharge would result; *B* is the completed case ten days after the release of the intermarginal adhesions and the fitting of a permanent eye.

An even or regular ectropion of one lid alone, especially if it is the upper, can be readily corrected by a flap from the brow. Ectropion of the lower lid alone is as easily corrected with a pedicle flap, but in this type of deformity a free skin Ollier-Thiersch graft, or even a true skin graft, gives a better looking end-result. Fuchs illustrates a manner of combining the methods of Fricke for the upper lid with that of Dieffenbach for the lower lid in those cases where both lids are involved (Fig. 341). A pedicle flap of sufficient size is taken from the forehead contiguous to the temporal extremity of the upper lid to move into a defect because of tissue lost and responsible for the ectropion. At the same time, a Dieffenbach triangular-shaped flap can be swung into a dissection defect in the lower lid. Such a defect would be formed after the release of all cicatrix and the return of the lid margin to its normal position. One must be assured that this type of surgery, however, is necessary before these gross pedicle flap plastics are carried out. Free skin grafts ordinarily give such satisfactory results that they should be utilized whenever necessary, but they cannot be used unless the operator can be reasonably certain of the complete removal of all scar tissue responsible for the ectropion. Failing the ability to do this (that is, in the presence of thick, unwieldy scar impregnated lids), then only is the combination of pedicle and sliding flaps, as here outlined, permissible and proper to be used.

Fuchs emphasizes that the cicatricial portion of the lid must be released by an incision parallel to the free border of the lid, and the more deeply situated cicatricial bands cut until the lid is freely movable and can be brought into its normal position without any strain being put upon it. Those portions of cicatricial skin which appear to have but little to do with malposition of the lid are spared as far as possible.

Schmidt corrects a scar tissue ectropion by two pedunculated curved flaps which he cuts from the lower border of the scar resection defect—one from without, the other one from within. The ectropion is corrected by bringing these two flaps upward to meet in the middle. This is made possible because of the shortening in the tendon of the orbicularis. Each triangular defect from which the flap is raised is then closed by bringing the skin up upon either side of a bridge of tissue lying originally between the apices of the flaps. In closing these defects the skin is sutured to this goblet-shaped bridge of tissue and not to the pedunculated flap above. Schmidt claims that following this operation the skin is smooth and uniform in color.

Laglayze has a rather similar technique. A crescentic incision is made through the skin and orbicularis of the lower lid as it lies in ectropion. The incision parallels the lid margin and lies about 1 cm. from the ectropic hair line. A second incision is then made paralleling the lid margin and immediately external to the line of cilia. This is to extend from canthus to canthus. A third incision connects these two. It is to extend from the

upper incision slightly medial to the mid-line and is carried down obliquely *to join the lower incision slightly lateral to the mid-line. The two flaps* which result are freed and lifted throughout their length. A suture is then placed into the apex of each, and the lateral of the two is carried up and into the greatest amount it can be reasonably stretched, while the more medial of the two is carried down and out a similar distance. These two *apical sutures are placed in their fixed positions* The other sutures necessary are then inserted The procedure is very satisfactory and the writer has used it in several instances in aged and infirm people where the least possible operative procedure was indicated but in whom full correction was desirable.

Richet uses similar transplantation flaps in the correction of an ectropion, especially when it is limited to the outer half or less of the lower lid A crescentic incision is made into the upper and lower lid, the external canthal angle is attached firmly immediately thereafter to the bone by a fine catgut suture. Intermarginal sutures are placed with three mattress sutures after elevating the lower lid margin to its normal level. This is done by opening the incision a sufficient amount to permit the margin to move upward and to lie in contact with the upper lid margin. From the end of the first incision a second is made curving down to the malar process, and a third is made from the middle of this last incision upward, terminating at the level of the canthal angle but 2 to 3 cm. temporally from it. The two flaps are then undermined. The smaller of the two is turned upward and sutured into the defect, lying with its apex out. Many forms of cicatricial ectropion at the outer third of the lower lid will respond nicely to this procedure.

Figure 343 illustrates an ectropion accompanied by loss of the lower margin of the orbit. *B* shows incision for the cartilage graft correction of the *bone defect*, *C*, the pedicle flap which followed the cartilage graft, and *D*, following the resection of this pedicle flap. The various techniques utilized have all been described.

There is one more consideration for pedicle flaps to be mentioned again here. It is relative to the use of large cervical flaps for the correction of a gross ectropion. Figure 197 illustrates a case. It is even possible to consider a greater necessity than this instance shows. The utilization of a large flap from the arm according to Berger's method would be the solution It is spoken of as the Italian method, in that Branca first practiced and Tagliacozzi subsequently continued it. Graefe first applied it as a modified form of blepharoplasty, though as Beard says, "The method has found scant favor in the eyes of modern surgeons and still less in the eyes of their patients." Derby[1] utilized it properly in an extensive burn with satisfactory results, and similar instances may arise. With Berger's technique[2] an exact pattern of the lid defect is cut from oiled silk, the arm is approached to the eye and the point that makes the easiest and most natural contact is marked in ink as the site of the pedicle. According to Beard, the pattern is then laid on in such a manner that the pedicle will be neither twisted, stretched, nor compressed, and so outlined that the area of the flap will be from that of one-third to one-quarter larger than that of the model. The subcutaneous fat, as well as the superficial fascia, are included with the

[1] Trans Am Ophth Soc, p 141, 1885

[2] Cong fran de Chir. séance du 4 session, p. 361, October, 1889

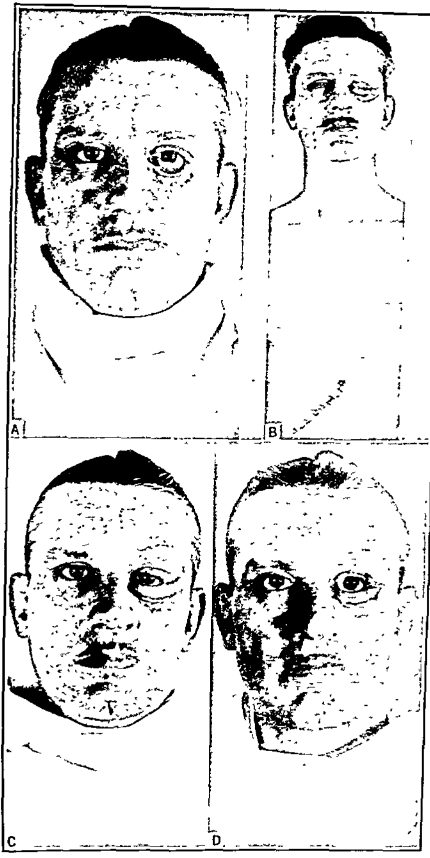


FIG. 343.—Combined cartilage graft and pedicle flap. *A*, defect from original injury. *B*, median tarsorrhaphy and incision lines for cartilage graft and chest incision for costal cartilage. *C*, pedicle flap in place. *D*, pedicle of flap resected and discarded.

skin. With the arm supported in position by a plaster cast, superficial silk sutures are used to hold the flap in place, while near the pedicle a few deep stouter sutures are inserted. The flap is dressed with a thin layer of cotton and with moderate pressure anteriorly, while posteriorly, the raw surface of the pedicle is covered with oiled silk. The site from which the flap was elevated is closed as much as possible with stouter dermol sutures, and a gauze dressing placed over the entire operative site. The pedicle may be divided at the end of the second week and the necessary surgery with the base of the pedicle completed.

In the utilization of flaps and scar resections for the correction of ectropion, many ingenious modifications of these various procedures must be invented and utilized. Each case is individual and demands individualized methods. Certain basic principles are necessary, which are recapitulated as follows. All scar possible should be removed. The flap, when moved into position, must support the lid margin. The suture lines present at the end of the operation should at no time lie in a line vertical to the lid margin, but should be obliqued, staggered or terraced. Pedicle flaps do not contract immediately more than a quarter of their cross surface under ordinary circumstances. A greater contraction will occur if it is permitted, but the sutures placing the flap should prevent it. When a flap has been cut and is ready for transplantation, this should be done immediately. Secondary defects may be closed later. The flaps should be kept covered with a warm saline soaked gauze dressing, while these secondary regions and defects are being sutured. Sufficient sutures may be used to hold the flap in satisfactory position. Only tiny bites coaptating the skin edges are necessary. *They need not be through-and-through, at least should not be* inserted deeply into the flap. The flap should be moved by sutures and not pinched with forceps. A moderate pressure dressing must be applied for the first forty-eight hours. At that time the dressing may be removed and inspected. A too-early exposure to the air is not beneficial to skin flaps nor to skin grafts. It is well, therefore, not to discontinue dressings before two weeks have elapsed. Thereafter they must be kept anointed for some time with a sterile mineral oil or sterilized olive oil.

The Epithelial Graft Correction of Ectropion.—There are two methods at our command—the use of full thickness dermo-epidermal grafts and the use of razor cut epidermal Ollier-Thiersch grafts. (Full thickness grafts should be spoken of as dermo-epidermal grafts, and the razor cut grafts which include only the superficial epithelium should be spoken of as epidermal grafts.) The full thickness grafts should be taken from the upper lid of the opposite eye whenever possible. If not, thin full thickness grafts, known as Wolff grafts (though they were first used by Le Fort) are used. (Ancient medicine shows that they were used by the Hindu surgeons for rhinoplasty.) The principles relative to the utilization of these grafts have been covered previously. The size of the dermal-epidermal graft to be used from the upper lid is limited naturally by the amount of skin which can be safely resected therefrom. Dermo-epidermal grafts from other parts of the body are not as viable, though such grafts have been utilized repeatedly of a size sufficient to cover completely an upper or a lower lid. Dermo-epidermal grafts resected from the hairless skin, immediately behind the lobe of the ear, though limited in size, have almost as high a percentage of successful takes as do those from an upper lid. The epidermal graft is not

limited at all in size. Its nourishment is drawn wholly from the vessels lying in the tissue beneath it, while pedicle flaps and dermo-epidermal grafts also must depend upon nutrition from the surfaces contiguous to which they are sutured.

Dermo-epidermal Grafts.—In the correction of ectropion, by the use of these grafts, all scar must be removed and intermarginal adhesions are certainly necessary. Dermo-epidermal grafts from the upper lid on the opposite side have been illustrated, page 249. In these instances the lid margin is incised through the cicatrix and brought down, or up, to a proper level with necessary traction sutures after removal of all cicatrix. The graft is then cut according to a pattern made from oiled silk. This is planned to fit in the defect accurately. Dermo-epidermal grafts from the upper lid of one eye shrink very little and allowances for this are not necessary. The secondary defect is closed with sutures after undermining, and a dressing over the graft completes the operation. Unless there is some important reason, the first dressing need not be done before the eighth day.

Dermo-epidermal grafts from other portions of the body are not universally satisfactory. The essentially useful portion of a graft is limited only to the epidermis. All other parts of the graft are subject to shrinkage and to cicatricial infiltration, and one is often astounded at the remarkable amount of shrinkage which will occur in some of these grafts after an apparently successful take. Beard feels that in general 75 per cent of the effect of a Wolff graft is ultimately lost. This amount is greater than in the experience of many others. Including all factors, however, it is sufficiently great that one must almost of necessity exclude their use except under unusual circumstances.

The cicatrix should be removed, the pattern for the necessary graft cut, and the lid margins sutured together without tension. The graft should be cut *either from the arm, or the thigh, or from behind the ear, upon the* same or upon the opposite side of the head. A graft should not be taken from the upper lid for the lower lid of the same side. If the graft is taken from the skin above the eyebrow, this naturally is not so important. These grafts are placed into position, with adequate sutures, and are held by a subsequent pressure bandage. It should never be necessary to use deep sutures in placing the whole skin type of graft. The graft, before it is used and after it has been lifted from the arm, should be carefully thinned by the removal of all subdermal tissues with sharp scissors and then sutured into place. Mattress sutures may be utilized to give good coaptation between the margins of the graft and the skin edges. For large dermo-epidermal grafts two or three stab wounds should be made at their widest part to prevent the retention of serum beneath them. These can be made just before the dressing is applied. One must be certain that all hæmorrhage has ceased before applying the dressing, and that there are no free clots or blood under the graft. At the time of the first dressing, if the graft is bluish in color (cyanotic), further stab punctures should be made to release the serum which is endangering its viability. Central blebs may form on the surface of some of the larger grafts, limiting decidedly the final result unless blebs are opened and the serum drained from below the graft.

Epidermal Grafts.—The first of the two procedures to be considered for the use of the epidermal graft is Esser's technique as worked out so satisfactorily by Gillies. This has already been covered under the consideration

of grafts in general. To repeat the technique here is unnecessary, but it is proper to call attention again to certain salient factors. After the mold has been fitted one should be able to just approximate the skin edges at the original incision line. The pressure dressing should be carefully applied and a Frost suture, as described under ptosis, is necessary in the normal lid to protect the cornea from the overlying dressing. Postoperative massage following this operation must not be omitted. When both lids are involved on the same side, if this method is used, the upper lid should be first repaired. If both eyes are involved, both upper lids may be done at the same time. At least four weeks should be allowed to elapse before the lower lids are corrected. A warning mentioned before may be repeated here. In the dissection necessary for these grafts, the scissors and scalpel should be applied immediately beneath the skin so that the muscles and the nerves are not injured; all scar tissue bands which can be reached must be removed. Fortunately, the method overcorrects the deformity, but this must not influence the operator in a diligent removal of the cicatrix. The author has never found it necessary to repeat this type of operation upon a patient because of insufficient correction.

FIG. 344.—Results from Esser inlays, *A*, before, and *B*, after surgery

Figure 344 illustrates another case wherein this method was utilized. The face was very heavily pigmented, however, from the original powder burns, and the grafts removed from the thigh are, by comparison, unfortunately and permanently conspicuous. A similar permanent pigmentation will also be seen when a graft is used from skin tanned by exposure to the sun; a warning applicable to epidermal as well as dermo-epidermal grafts.

Reference must again be made under the corrective operations for ectropion to that of Wheeler. This is especially applicable to severe deformities following the more extensive burns, the ectropion involving both lids. No other operation is as satisfactory as this one for those severe types of ectropion wherein the lid margin of the upper lid may be raised as high as the level of the rim of the bony orbit, and the lower lid everted to a complete loss of the cul-de-sac. To abstract the essentials: the ectropion must be released by adequate dissection and the lid margins approximated; if the ectropion involves both upper and lower lids, they are to be corrected simultaneously; two or three intermarginal adhesions are to be arranged (small rectangles of the lid margin are removed posterior to the line of cilia,

these rectangles first outlined with a cataract knife and then removed with small sharp-pointed scissors—one should be careful that the areas in both upper and lower lid are in accurate apposition); dissection at the outer canthus may be as free as is desired and necessary; it should not cross over the inner canthus, however; any defects there must be subsequently corrected; as soon as the lid margins are freed and at a normal level, mattress sutures are to be passed from the lower lid through the areas of marginal denuda-

FIG 345 —Results from the Wheeler technique. In *A*, the median tarsorrhaphy is still present, this has been sectioned in *B*

tion into the upper lid (the writer now passes these mattress sutures under the skin remaining at the lid margin of the lower lid, through the marginal region in the upper lid, and out upon the skin there still remaining, tying them rather tightly through two tiny flat perforated plates of rubber): absolute hæmostasis is necessary; the graft is cut and then placed over the operative defect; before the dressing is applied the graft should be slit for a short distance in the line of the palpebral fissure to allow the tears to pass through the graft into the overlying dressing without lifting the graft in a bullous-like manner; two methods are available for the dressing, in the first

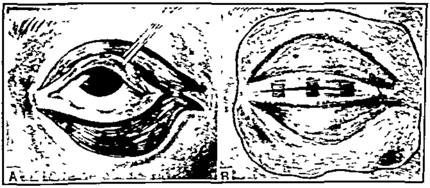


FIG 346 —The Wheeler technique for ectropion (Courtesy of P. Blakiston's Son & Co)

a layer of oiled silk or paraffin impregnated gauze is stretched smoothly over the graft and a dry sea sponge bandaged immediately thereon giving firm and elastic pressure (both eyes should be covered for the length of time that this dressing is applied); the second form of postoperative dressing, and the one which the author has been using almost wholly for the past several years, is the use of a shell of dental stent which has been molded to the face while still warm and semifluid, the site prepared for the graft,

this and the graft are both covered with warm sterile petrolatum, the skell placed directly upon the graft and then bandaged thereon with an overlying sea sponge and with gauze fluffs sufficient to give firm but elastic pressure.

Figure 345 shows the correction obtained by this method. In *B* the intermarginal adhesions have been sectioned, but the lids in *A* are still adherent.

Wheeler, in his original technique, uses three areas for his intermarginal adhesions. Figure 346, *A* and *B*, are copies of his original illustrations.

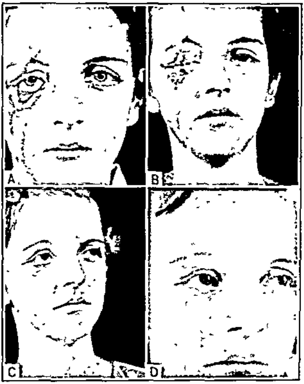


FIG. 347.—Complicated ectropion, assisted in correction by a cartilage graft *A*, before correction, *B* and *C*, during surgery, *D*, completed result

In reviewing the operation, attention is called to several important points connected with it. Neglect of these will mean the difference between failure and a satisfactory result. Very careful dissection must be practiced to conserve any muscle tissue remaining under the scar. When the lid adhesions are cut, the operator should be positive that all contraction has ceased in the reconstructed lids. There are several ways of determining this: the rigidity of the lids, determined by palpation with the finger tips; the size and the shape of the spaces between the lid margins and between the intermarginal adhesions; the ease with which the lid surfaces can be lifted away from the globe of the eye or from the contained intra-orbital molds with fixation forceps; the time intervening since the operation; and the amount of scar present and removed at the operation. The adhesions may be left for an indefinite time, from twelve to eighteen months, if necessary.

The operation, if required, can be repeated without any serious difficul-

ties. While the patient has the intermarginal adhesions, tinted lenses with dark rims will make the postoperative deformity appear less conspicuous. If the operation is done over a socket which has no natural globe a well fitted mold of gutta percha must be made and placed into the socket before the operation. Dental compound cannot be used because of the necessity for retaining this mold in the socket for a long time. Under such conditions dental stent deteriorates, becomes softened, is irritating, and decreases in size.

Figure 347 is a complicated case of ectropion corrected somewhat differently. The condition resulted from a third degree burn due to contact with a hot pipe. The defect in the upper lid had to be assisted by a cartilage graft due to some bone destruction there. Cicatricial contraction was marked because of the keloid across the face. After resection, by Ivy, this was further improved by roentgen-ray therapy as can be seen in the end-result one year later. The cicatrix in each upper and lower lid was resected and the lid margin forcibly returned to its normal level. A razor cut graft was placed into the lower lid and a free skin graft from the opposite lid simultaneously in the upper lid. The lid margins were sutured together by permanent intermarginal adhesions, and dressed with a pressure shell of dental stent.

Ear cartilage from the shell of the ear is available for both the upper and the lower lid in reconstruction connected with these two. In general, however, when cartilage is to be used alone, a thin scale of costal cartilage gives better results. When both the cartilage and the overlying skin are needed for filling in a defect, poor union is likely to occur when edges of ear cartilage are sutured to the edges of the tarsal plate. Lowenstein,[1] taking his cue from the work of Budinger and Müller, devised a new procedure. He outlined, on the shell of the ear, a piece of cartilage and skin which will approximately fill the defect. The cartilage was then denuded a few millimeters farther, thus obtaining sufficient cartilage to overlap the aperture. Having freshened the edges of the defect and undermined the skin, he inserted the implant, imbricating the cartilage and tarsus and providing ample surface contact to insure firm union. It is to be fastened into position by through-and-through mattress sutures placed on each side, the skin being approximated by fine sutures. He also used ear cartilage to replace the tarsus following tarsectomy, and advises this as routine procedure to be done simultaneously with the tarsectomy. He also considers this material superior to mucous membrane for intermarginal grafts, as used by Goldfeder.

It may be necessary in many of these instances to pass mattress sutures through the inferior or the superior cul-de-sac at the inner angle of the upper and the lower lids to deepen the cul-de-sacs at these points, as has already been illustrated and discussed in inferior and superior cul-de-sac restoration. This should be done whenever satisfactory eversion cannot be obtained after the removal of the cicatrix.

ENTROPION AND TRICHIASIS

This condition is less common than ectropion, though unfortunately not as easily corrected. There is one basic point present in all corrective

[1] Klin Monatsbl f. Augenh., 93, 320, 1934; Year Book Eye, Ear, Nose and Throat, 1935.

operations for it. The different operations devised for it are certain to fail unless the bent and deformed tarsal plate is in some way straightened, or partly or wholly resected. If it were not for this, the simple resection of a horizontal crescentic piece of skin, external to the lid margin, would be sufficient to evert the entrophic line of lashes and thus correct the deformity. As a matter of fact, in certain types of entropion, little more than this is needed, as in the spastic entropion occasionally complicating early blepharitis and blepharophimosis.

To recapitulate: the necessary factors in an operation for entropion[1] are: "(1) it must relieve the faulty position of the cilia; (2) it must prevent the subsequent recurrence of this faulty position; and (3) it must fulfill the foregoing requirements with the least amount of disfigurement" The third requisite is the most difficult to fulfill. In a large number of cases, entropion is connected with conjunctival cicatrices and has as a basis, distortion of the tarsal cartilage with or without some symblepharon. It is quite evident that these elements must be considered in the surgical correction of every case under treatment. Meller subdivides surgical procedures for these conditions into four general groups.

1. The first group is applicable to senile and spastic entropion and trichiasis. These are corrected by shortening the skin of the eyelid, either by resection of a horizontal fold of skin, or by the insertion of properly spaced sutures.

2. Meller's second group considers largely entropion and trichiasis of cicatricial origin, those cases with mechanical shrinkage of the conjunctiva, and cases with changes in the tarsus. For this group, we must consider procedures in which the pathological condition is removed by excision of the cicatricial tissue and the dense thickened tarsus, while the loose skin of the eyelid is reattached to the anterior convex surface of the tarsus. We cannot include cases of entropion with symblepharon due to traumatic conjunctivitis. Free mucous membrane grafts are necessary for correction of this condition.

3. The third group of Meller's classification includes only disease of the hair follicles.

4. The fourth group of Meller's classification involves removal or transplantation of the cilia without correction of the accompanying entropion. Either procedure is more applicable to trichiasis than to entropion. The first is Flarer's method of ablation of the line of cilia. The writer believes that this is never indicated. The disfigurement which occurs is unsightly, for the loss of the lashes is a defect which cannot be lightly dismissed

The first group includes the use of certain sutures. In this, the inward rotation of the eyelid is corrected by an anterior folding of the skin. This gives a temporary shortening of the eyelid perpendicularly, and it is presumed that a permanent shortening will be produced by the formation of a cicatrix.

The Gaillard suture is double-armed, introduced with curved needles. Each needle is inserted at 2 or 3 mm. from the skin edge, depending upon the height of the inverted eyelid. It is then carried downward anterior to the tarsal cartilage to emerge through the skin 3 mm. below the point of the insertion. The opposite end of the same suture is introduced 3 mm.

[1] Spaeth, in Berens Textbook of Ophth., p. 1045, 1936.

from the first. The two sutures lie at the junction of the inner and middle, and outer and middle thirds. As they pass downward they should diverge slightly. After both sutures are placed they are tied over a small roll of gauze with an equal amount of pressure, or through two perforations of a small flat rubber plate. The tension placed on these sutures, when tied, should be sufficient to evert the eyelid margin from its malposition and to hold it in the new position.

The Snellen entropion suture is slightly different. Each end of a double-armed suture is passed from within the lower cul-de-sac, through to the surface of the eyelid, then passed back again at its point of exit, immediately beneath the surface of the eyelid, to emerge on the eyelid margin, just anterior to the line of lashes. The sutures are tied with tension to evert the eyelid margin, and are left in place for from two to three weeks. The writer has left them in place as long as six weeks and obtained thereby a full correction of spastic entropion. The sutures are best adapted for entropion of presumably short duration.

The Graefe operation is the only one which shortens the skin of the lid satisfactorily. The author has seen very satisfactory results from this procedure as done by Meller. Meller's technique[1] for the operation is as follows: He makes his first incision parallel to the lid at a distance of 3 mm., and from both ends of the middle third of this cut, two other incisions are made downward, which uniting, form an equilateral triangle. The area of skin outlined is excised, and the edges of the wound slightly undermined. The first suture approximates the two lateral angles of the wound. If it is too near the edge of the lid, the stretched skin presses the free border of the lid backward and increases the entropion, and if inserted too low, below the tarsus, it naturally has little or no influence on the position of the lid. It is therefore important that the first incision be parallel to the edge of the lid, and correspond approximately with the lower border of the tarsus. The rest of the wound is closed by additional horizontal sutures. The skin is shortened horizontally, exactly at the lower border of the tarsus, and the latter is pushed toward the eyeball, while the free border of the lid is rotated outwardly from the eyeball. A gauze compress bandage should be used to hold this rotation while the wound is healing.

Wheeler's orbicularis transplantation is also quite satisfactory for this type of entropion. It is especially valuable in the spastic form. His technique[2] follows herewith. "An incision is made in the lower lid about 5 mm. from the margin extending nearly the whole length of the lid. Above and below the incision the skin is dissected from the orbicularis and a strip of orbicularis muscle 4 mm. wide is dissected up. This strip is taken from the muscle just below the lower border of the tarsus. It is cut in the center, but left attached at the ends. Then a 3-0 catgut suture is carried through the tarso-orbital fascia about 2 mm. below the tarsus. It is then carried through first one flap of the orbicularis strip and then the other, so as to force an overlapping of 4 or 5 mm. The suture is then tied, and the overlapping is made secure by two additional sutures. The skin wound is closed and a secure dressing is applied."

In the final analysis, the mechanics of correction are similar to those for the Graefe operation, in that the pressure posteriorly applied by this over-

[1] Meller, Ophthalmic Surgery, P. Blakiston's Son & Co., 1924.
[2] Collected Papers of John Wheeler, p. 413.

lapping strap of orbicularis fibers tips the tarsal plate outward into a corrected position.

The Hotz-Anagnostakis operation fulfills well the requirements in the second group. A horn plate is necessary to protect the eyeball and also to give a firm working base. An incision is made along the entire length of the eyelid, parallel to and 2 or 3 mm. from the eyelid margin and both upper and lower edges undermined—the upper to the orbito-palpebral fold, and the lower to the lid margin. The incision is carried through the muscle to the tarsus. The hypertrophied muscle fibers are resected after they have been removed from the anterior surface of the tarsus. If the tarsus is not badly deformed, it need not be excised. However, if there is a marked deformity, a horizontal wedge-shaped section may be cut from its anterior surface, through its central portion, so that it will fold outward and become flattened in the subsequent closure of the wound, or from its inferior border,

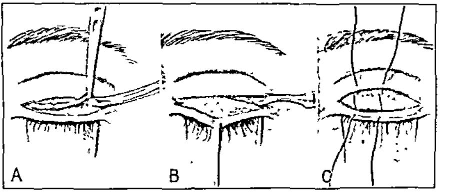


Fig. 348.—*A*, Hotz-Anagnostakis operation Excision of the fibers of the orbicularis muscles covering the tarsus With forceps the fibers are grasped at the left angle of the incision; a pair of small curved scissors is applied close to the tarsus and with short cuts the muscle is separated along the entire length of the lid. *B*, with the knife applied against the convex anterior surface of the thickened tarsus, thin slices are cut The upper border of the tarsus and the margin of the lid are not disturbed. *C*, two of the sutures are applied They pass from above through the skin, then through the upper border of the tarsus in which they are firmly fastened, and lastly through the lower margin of the skin above the cilia corresponding to the convex form of the lid The upper suture is nearer the lower margin of the wound than the middle suture (Courtesy of P Blakiston's Son & Co)

as Wiener does. Most cases of trachoma with entropion will need this additional dissection in the tarsus. The tarsus itself should not be perforated. The wound is closed with four sutures, inserted as follows (the two central ones being placed first): The needle is passed through the upper skin edge of the wound, then through the tarsal orbital fascia and the upper edge of the tarsus. (Meller recommends that the sutures be carried through at this point in a horizontal direction.) The suture then is passed across the site of operation and through the lower lip of the skin wound The sutures are tied, the middle ones first, and as the edges approximate. the convex tarsus is flattened anteriorly and the defect in the orbicularis closes. The eyelid margin also moves upward to become attached to the anterior surface of the tarsal cartilage in such a position that the trichiasis or entropion is permanently corrected. A moderate overcorrection is present when the operation is completed. The remaining sutures are then tied, and the eye is dressed as for ptosis. The sutures may be removed on

the sixth day. The operation is more suitable for trichiasis which lies in the central arch of the eyelid than for one lying nearer the angles. The eyelid is not shortened following recovery. Because the easiest correction for trichiasis is at the central portion of the eyelid, it may be necessary to augment the correction at the angles by a short intermarginal incision at these points and the resection of a piece of the skin. The operation is not so satisfactory in the lower eyelid, as in the upper eyelid, because of the narrower tarsal cartilage. Figure 348 illustrates the technique. In the lower eyelid it is better to utilize Streetfield's and Snellen's recommendations of excising a wedge-shaped piece of the tarsus before closure, or Ewing's procedure.

The Ewing operation will correct a small number of these cases, especially when there is a minimum amount of tarsus deformity and but little cicatricial contraction of the conjunctiva. It is equally satisfactory for entropion of either eyelid. The posterior surface of the eyelid is incised, parallel to the eyelid margin, and through the middle of the tarsus for its entire thickness. Five mattress sutures are then passed from the posterior surface, upper conjunctival lip, of this incision, through the depths of the incision to the eyelid skin surface, to emerge near the line of eyelashes, and there be tied. These sutures thus drag a wedge of tissue into this incision, fold out the bisected tarsus and hold it in hinged eversion during healing. From three to five sutures are necessary.

Ewing's technique is apparently based upon Green's original operation, which was rather similar anatomically. In addition to the tarsus incision, Green removed a thin strip of skin upon the anterior surface of the lid and then passed his sutures through the lid so that they not only everted the ciliary border but closed the skin wounds as well. In their introduction the needle was first passed through the edge of the lid behind the line of cilia brought out through the skin wound and then reintroduced through the skin incision across the anterior surface of the tarsal plate to emerge slightly less than 1 cm. above their point of entrance.

Ewing's operation[1] consists essentially in dissecting the tarsal conjunctiva away from the tarsus from a short distance behind the opening in the meibomian glands to a width of about 5 mm. and then suturing the loosened conjunctival membrane into the bottom of the angle of the tarsal incision. In this manner the sutures, when tied, caused a gap to be formed at the line of incision, thereby everting the lid margin.

Several modifications have been made of this technique by Ewing as well as by other operators as Wiener, Green, and the author. Smith and Siniscal[2] use local anesthesia;

To elevate the conjunctival cul-de-sac after everting the lid and make a curved linear incision parallel to it along the full length of the lid margin but about a mm from it. The incision comes from beneath the conjunctiva and tarsus and is completed through the entire tarus. The tarsal plate is then separated from its adherent muscle fibers for a distance of about 4 or 5 mm. from its two edges. A few strokes with the blunt edge of the scalpel are sufficient for this. Alternate white and black armed silk sutures are used not only to close the wound but also to serve in the reconstruction of the lid by making traction on the detached portion of the cut tarsus thus effecting eversion of the cilia bearing margin. Four to five sutures are necessary, two temporally, two nasally, and perhaps one in the mid-line. The cut

[1] Trans. Am. Ophth Soc., 9, 15-18, 1900-1902.
[2] Am. Jour. Ophth., Ser. 3, Vol 26, No. 4, April, 1943

margin of the standing tarsus together with the adjoining conjunctiva is grasped firmly with a forceps, and one needle of each suture is passed through about 1 mm. or more from its edge proceeding from conjunctival surface to muscle surface (deep). Then a fellow needle is similarly placed about 2 mm. distant from the first. It is important that one needle include the conjunctiva with the tarsus when inserting the needle. The clamps are then removed, and the needles are inserted through the lid margin entering the latter at the cut edge, piercing the detached tarsal strip that remains attached to the lid margin, and emerging in the line of cilia. The fellow needle of each suture is inserted through the depth of the incision proceeding from inner to outer lid surface so as to emerge at a point on the skin surface approximately 4 to 5 mm. behind the line of the cilia. When all of the sutures have been placed in this manner their ends are securely tied over a suture strip.

The operation lends itself best to the upper lid; the lower lid, however, can be equally satisfactorily corrected.

Meek recently demonstrated an operation for spastic entropion which utilized the pull of the orbicularis fibers by reversing the normal concavity of these fibers in relationship to a different type of curvature, that is, a convexity. At the same time, Busacca's contention that entropion results *from and is accompanied by hypertrophy of the orbicularis is rectified. It is* not certain nor especially important whether the transplanted fibers continue to function as muscle fibers, or remain as a cicatrix within the orbicularis itself. Because of this vertical cicatricial (?) pull, it is not the best procedure in those instances wherein entropion is accompanied by a relaxation of the lid. The fibers of the orbicularis are already insufficient, in these cases, and hence should not be utilized. The technique of the operation as sent to me by the author subsequent to its presentation[1] and the author's illustrations follow herewith.

A 2 per cent solution of procaine hydrochloride, with 2 drops of epinephrine hydrochloride to the cubic centimeter, is injected subcutaneously along the entire length of the lower lid from the margin, covering an area 1 cm wide. (Fig 349, *A*) The under, concave surface of the broad end of a Jaeger plate is greased with petrolatum and slipped under the lower lid The concavity is toward the eyeball

An incision is made the entire length of the lower lid 3 mm from the margin The lower flap is undermined 3 mm., and the upper one is undermined 1 mm (Fig. 349, *B*) Two flaps of orbicularis oculi muscle, each 4 mm. in width and tapering at each end, are first outlined with a knife and then dissected up from the tarsus, one from the direction of the external canthus and one from the direction of the internal canthus. The muscle is left attached to the tarsus in an area 7 mm wide with its center just temporal to the center of the lower margin of the lid (Fig. 349, *C*.) An incision is made with a knife, 25 degrees temporal from a point below the center of this attached muscle down to the anterior surface of the inferior orbital margin.

A suture of 000 plain catgut is passed through the periosteum. A Yankower needle is useful here. The muscle flap is loosely sutured into place on the anterior surface of the inferior orbital margin. A similar incision is made 25 degrees nasal to the center of the attached muscle, and the other flap is sutured loosely in place on the anterior surface of the nasal orbital margin (Fig. 349, *D*) The skin is then closed with interrupted black silk sutures. A pressure dressing is applied, and the wound is not dressed for three days. The flaps of muscle must be attached loosely to the anterior surface of the orbital rim, because it is easy to overcorrect the defect and draw the lid away from the eye if the muscles are tightly attached.

Cases of insufficiency of the orbicularis should be corrected by Wheeler's orbicularis transplantation, because in this procedure, the correction is obtained by pressure against the anterior surface of the tarsal plate.

The simplest operations for the third group is the simple Snellen opera-

[1] Arch. Ophth , 24, No. 3, 549, September, 1940

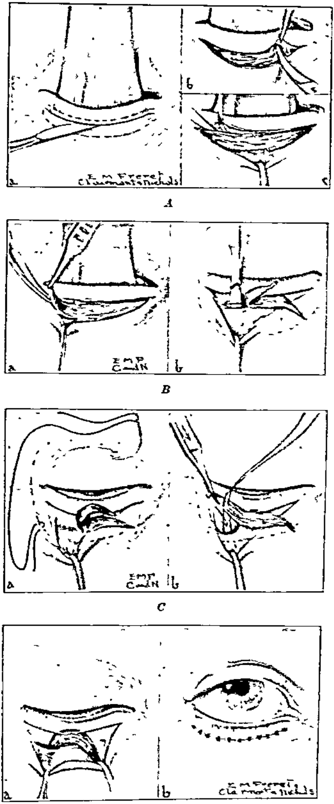


FIG. 349.—Meek's technique (see text), for spastic entropion. (Personal communication.)

tion or the Panas modification thereof. The skin of the eyelid is divided 2 or 3 mm. above the free border of the eyelid and parallel to the latter, the incision running the entire length of the eyelid. Beginning at this incision the skin is resected as far down as the free border of the eyelid and as far up as the upper border of the tarsus. Then by cutting down upon a horn plate an incision is made parallel to the incision in the skin, thus dividing the tarsus throughout its entire thickness, including the tarsal conjunctiva. If desired, a thin wedge of the tarsus may be removed instead of a simple linear incision (Streetfield). By this incision the marginal half of the tarsus is made freely movable, so that with sutures it may be everted sufficiently to obtain a complete correction. The four sutures are placed as follows: The needle on one end of the suture is passed horizontally through the tarsal-orbital fascia and the upper margin of the tarsus, but not through the skin surface. Both needles of the suture are then passed through the muscle and tarsus of the lower free flap, and brought out in the line of cilia. The sutures are tied over a small rubber plate, or, as Meller recommends, over a glass bead. All sutures may be removed on the fifth or sixth day. This procedure is as satisfactorily applied to the lower eyelid

Vogt's operation for entropion as described by Schlapfer[1] consists of injecting anesthesia into the outer angle and making a canthotomy opening external to the orbital bones. A suture is placed through the cut in the skin and out through the epithelial edge of the upper lid, then continued across the canthus through the conjunctiva of the lower lid and out through the incision line. When tied, the suture everts the lid margins to form firm external adhesions. After this suture is tied, additional ones may be utilized if necessary. Vogt considers it as an operation of choice for severe entropion and for those cases operated on by other methods without improvement.

Meller's Fourth Group.—The procedure outlined by Machek and Blaskovics for Meller's Fourth Group is very satisfactory (Fig. 350). It is done under local anesthesia. The eyelid is supported upon a horn plate, and an incision is made along its full length at the marginal junction of skin and conjunctiva posterior to the line of cilia. A second incision is made 3 mm. above the line of lashes and parallel to this. A third slightly shorter and slightly convex incision is made above the second, with its extremities arising from it. The second and third incisions are carried down to the tarsus The marginal incision is deepened by sharp dissection so that a bridge or hammock-like flap is formed. By means of forceps the position of these two flaps is reversed. The narrow and slightly spindle-shaped flap outlined by the second and third incisions is moved toward the eyelid margin, passing under the bridge of skin. This latter is then anchored to the tarsus by two mattress sutures, which hold it in position and at the same time hold firmly the narrow flap moved into the eyelid margin. All skin edges are closed with a few very fine sutures, and a dressing is applied. The sutures may be removed on the fourth or fifth day.

The Spencer-Watson operation is satisfactory when the trichiasis lies at either the inner or outer angle of the margin of the eyelid. The technique is as follows: After the horn plate has been inserted, an intermarginal incision is made with an angular keratome or scalpel. The length of the incision depends upon how far the trichiasis extends, but should be 2 or

[1] Klin. Monatsbl f. Augenh , 94, 610, May, 1935.

3 mm. greater than that area in which the cilia are misplaced. A second incision is made starting about 3 or 4 mm. from the first, the canthal end being connected with the intermarginal incision. The third incision is parallel to the first and is started from the end of the second. Both of the latter incisions should be 2 or 3 mm. longer than the first. The two flaps thus formed by the incision are dissected free and then interchanged. Sutures are now inserted to hold the flaps in place, and a bandage is applied. The sutures are removed on the fifth day (Fig. 351).

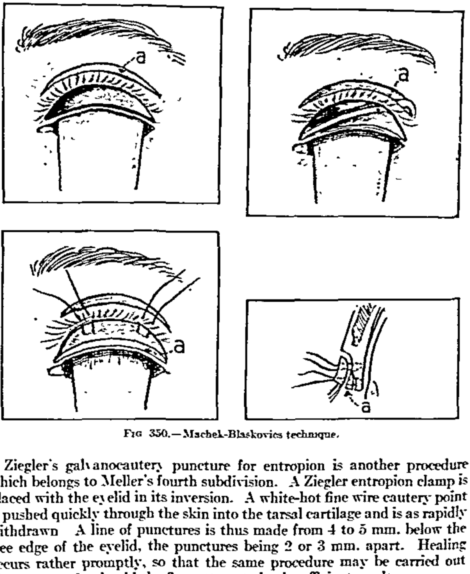


FIG 350.—Machek-Blaskovics technique.

Ziegler's galvanocautery puncture for entropion is another procedure which belongs to Meller's fourth subdivision. A Ziegler entropion clamp is placed with the eyelid in its inversion. A white-hot fine wire cautery point is pushed quickly through the skin into the tarsal cartilage and is as rapidly withdrawn A line of punctures is thus made from 4 to 5 mm. below the free edge of the eyelid, the punctures being 2 or 3 mm. apart. Healing occurs rather promptly, so that the same procedure may be carried out after two weeks should the first attempt give insufficient results.

Van Milligan's technique of a free mucous membrane graft belongs to this same subdivision. By means of the operation a very satisfactory correction may be obtained in the upper eyelid. The margin of the eyelid is incised immediately posterior to the line of the lashes, and parallel to the margin, for its entire length. The skin of the eyelid is then elevated to the orbito-palpebral fold. A crescentic-shaped portion may be resected at the

orbito-palpebral fold, though it is not usually essential. If the skin appears redundant, it is perhaps wiser to do this. Two double-armed sutures are passed through the skin at the lid margin, from the central point of the outer and inner thirds, slightly anterior to the line of lashes, and these are

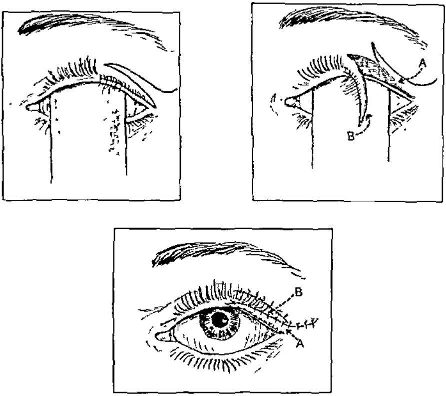


FIG. 351 —Spencer-Watson's operation for partial trichiasis

FIG. 352 —Entropion, cicatricial at inner canthus.

then passed subcutaneously beneath the eyebrow to the skin of the forehead above the eyebrow; quite as one would pass sutures for a Hess ptosis operation. Between these two sutures and very close to them, a second pair of double-armed sutures is passed downwards from the extremes of the middle third of the lid surface, arising from the lower portion of the fascia

over the tarsal plate and emerging on the skin surface just anterior to the line of lashes and very close to the position of the first two sutures just described. These four sutures, when tied, have important functions; the latter two anchor the lid margin with the lashes, which formerly were in trichiasis, upward and away from the conjunctival surface. At the same time, when tied (and these are tied first), they give a firm support for the first of the two pairs of sutures which are now tied (secondly) and which correct the moderate degree of ptosis almost universally present in these cases. The incision, or the site of the resection, in the orbito-palpebral fold is then closed with interrupted black silk sutures. The silk for the paired four sutures should be a waxed No. 1 twisted black silk. The mucous membrane graft is then cut from the buccal mucosa, trimmed to a proper thinness, and then cut to an exact pattern of the defect which must be cor-

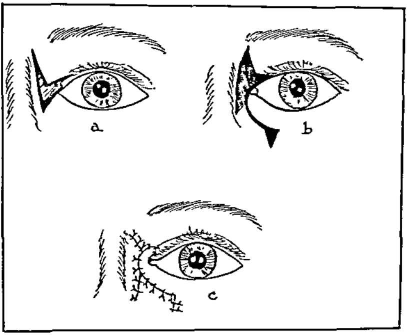


FIG 353.—A sliding flap technique for the correction of Figure 352.

rected. This defect lies between the line of the lashes and the free cut edge of the conjunctiva of the upper lid. Twisted, waxed, black silk sutures are used to suture this into position. If three fine sutures are first placed from the skin edge to the conjunctival edge, one at the middle point of the outer third and one at the extremity of the lid margin defect, the mucous membrane graft can be slipped between the loops of these and it will be held accurately in position by tying them lightly. Further sutures as are necessary can be placed without difficulty. These looped sutures enable one to tuck the edge of the mucous membrane graft close to the edge of the skin surface so that absolute approximation is obtained. One must be certain that the fine black silk sutures anchor the two extremities of this graft into the apices of the lid margin incision at the inner and the outer canthal angles. The punctum must remain attached to the lid margin. Figure 354 illustrates the sutures and a sketch of the completed result; also the sketch

of the cross surface of the lid illustrates the position of the sutures and of the mucous membrane graft at the lid margin. The operation is completed by a suture in the lower lid margin, as advised by Frost, so that when the dressing is applied, the lower lid can be brought up across the cornea, protecting this from any damage which might occur because of the moderate pressure which must be applied with the postoperative dressing. This dressing consists of a piece of well oiled silk overlying the palpebral fissure. Immediately thereon, a finely-grained, dry, sea sponge is placed, and the hollow spaces about it and over it filled in with tufts of dry absorbent cotton. A piece of gauze is placed upon this, and if both eyes are corrected

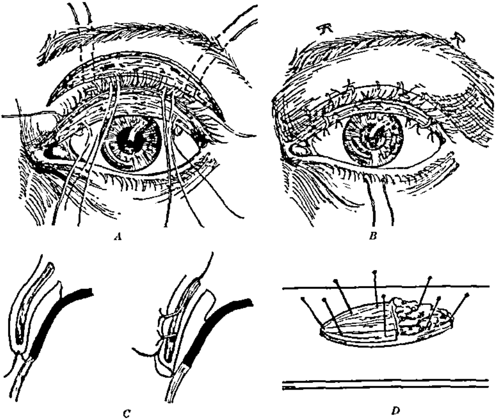


Fig. 354.—Spaeth's technique for the van Millgan operation (Courtesy of Jour Am Med Assn)

simultaneously, a figure-of-eight bandage should be applied binocularly. In correcting both eyes simultaneously one must be certain that the amount of mucous membrane which has been resected is adequate for the two lids. In the technique for this operation the lashes are permanently elevated from contact with the cornea, and at the same time an accompanying ptosis is corrected. The technique as given is the author's modification and is a combination of ptosis sutures plus the correction for the entropion.

In general, entropion of scar tissue contraction origin must have a threefold correction; the hair line must be replaced, the deformed tarsal plate straightened, and the limited conjunctiva restored with mucous membrane grafts or with epithelium if the eyeball has been lost; otherwise mucous

membrane. All three of these facts are seldom present in any one case. The first two mentioned are most common. Figure 352 illustrates this. The entropion, at the inner angle, with the relative epicanthus, was corrected by a relaxing incision (see Fig. 353), and subsequent to this, a sliding flap from the inner angle portion of the lower lid. (Both canaliculi had been destroyed.) The hair line, canthus, and the drag on the upper tarsal plate were all simultaneously corrected. Figure 353 outlines the necessary technique used.

The Hotz, de Wecker, Oettingen, Kostomyris, Meller, Panas, and other various sutures for this condition have as their basic principle either a transplantation of the line of lashes, or a rearrangement of the muscle fibers normally attached to the peripheral border of the tarsal plate. (The method of Panas differs somewhat in that his dissection aims to separate the tarsal plate into two segments so that the one nearer to the lid margin is freely movable and thus can be twisted outward and upward, or downward, by the sutures.)

The technique of this is somewhat similar to that of the Snellen operation, but it is a bit more radical. Further, the postoperative appearance is not as satisfactory as that seen following the Hotz-Anagnostakis procedure. In the Snellen operation an incision is made in the skin of the lid similar to that described in the Hotz operation. The wedge is then cut out of the thickened tarsus as outlined by Streetfield, the section to be removed being from 2 to 3 mm. in width and being cut obliquely, so that the two incisions outlining this piece to be resected meet against the conjunctiva but without perforating it. The entropion is corrected and the wound closed by two double-armed sutures passed from the upper edge of the tarsus resection incision into the lower edge, and from there continued through the tarsus and the lid to appear upon the skin surface slightly above the cilia. They are tied there over glass beads or upon a roll of gauze. The Panas operation does not resect any portion of the tarsus or of the lid. After the lid incision is made, the tarsus is cut horizontally throughout its entire length so that the lower half of the lid is easily movable, being now attached to the remaining portion of the lid structures only by the conjunctiva. Four double-armed sutures are to be used. One needle of each of these is passed horizontally into the tarsus immediately above the margin of the cut. Both ends are then passed between the orbicularis muscle and the tarsal plate of the lower portion of the lid, emerging slightly above the line of lashes. All four sutures are treated in this way. Each is then tied over a tiny glass bead. Beard places the sutures in his Panas suture technique as single-armed sutures, closes the skin incision with them, and anchors them to the forehead during recovery. The author is inclined to think that this is a rather satisfactory modification.

The method advanced by Snellen is recommended as satisfactory for many cases for, if necessary, the effects of it can be increased by means of a mucous membrane graft.

De Peyrelougue calls attention to a plastic operation for entropion and trichiasis which he has used with satisfaction over a period of five years and which is a modification of the Snellen operation. In this operation the cartilage is exposed through a skin incision just above the lashes, and a wedge shape resected from the plate throughout its entire length, 2 to 2.5 mm. in width. The sutures, three or four in number, enter the lid just

rection obtained at the close of the operation persists after healing is complete. Beard combined a canthoplasty with the Hotz procedure, countergrooving of the tarsus and tucking of the orbito-palpebral fascia with a mucous membrane graft from the lip (cheiloplasty) so commonly that it was spoken of as the "altogether operation."

When cicatricial entropion of the lower cul-de-sac is to be corrected by free skin epidermal grafts (see p. 150), the same dissection is carried out until the lower fornix or the fornices have been well opened and all cicatricial tissue removed.[1] The graft (one of minimum thickness being necessary) is then cut, wrapped over a metal conformer with epithelial surface innermost, and placed in position. The eyelids are closed by a temporary tarsorrhaphy. The conformer may be removed for irrigation of the cul-de-sac after the sixth day, this being the time for the first dressing. This presupposes an absent eyeball.

Essential atrophy of the conjunctiva, also spoken of as essential shrinkage of the conjunctiva, and as pemphigus, is a condition which must be corrected with a mucous membrane graft. Even though the entropion is corrected, the cornea may continue with its course of vascularization and opacification, but there is no doubt, it seems, that this is delayed (personal conversation with Gifford confirmed this opinion.) The surgery is simple if carried out properly. In these cases, in addition to the mucous membrane graft (which see), the lid margins are incised posterior to the line of lashes and intermarginal adhesions arranged between the upper and the lower lids. Snellen or Gaillard sutures are placed through this incision line quite similarly to the Hess sutures for ptosis as applied to the upper lid. The removal of a crescentic section of skin and of orbicularis completes the operation.

Raubitschik has an operation by which he has obtained good results in all of the 27 patients on whom it was performed. He makes a cutaneous incision 1 mm. above the tarsus and resects a 2 mm. portion of the tarsus. The tarsal wound is closed by a running suture which is not fastened but remains in the tarsus by friction. The cutaneous wound is closed by a subcuticular suture. His operation does prove the claim that the effect of tarsectomy does not depend upon the sutures but upon the reshaping of the bent tarsus.

In 1921, Trautar, of Paris, presented an operation which he has used for six years in entropion of the upper lid. He exposes the tarsus and makes a vertical incision in the tarsus near the temporal end, this incision being made perpendicular to the surface, not obliquely, and with the cutting edge of the scalpel facing away from the conjunctiva. The section is raised and the temporal portion of the tarsus dissected off with sharp scissors. He combines three loop sutures with the operation, but removes them at the end of seven days. If the tarsus is irregular and calloused, he does a complete tarsectomy.

In 1824, Emile Junes[2] reported an operation for trichiasis which he states was successful in over 100 cases.

(1) Injection of 2 cc. cocain-adrenalin is used and a Jaeger plate under the lid. (2) At 2 to 3 mm. from the margin of the lid, an incision is made from one angle to the other, through the whole thickness of the lid, includ-

[1] Esser. Epitheleinlage als conjunctival Ersatz. Klin. Monatsbl. f. Augenh., 63, 374, 1919
[2] Clin. Ophth., Paris, p 275, May 28, 1824.

of the tarsus denuded close to them. All of the muscle bundles between the superior and the inferior muscle incisions are grasped and removed with a forceps. A linear incision is then made on the tarsal plate 5 to 8 mm. from the free border of the lid and parallel to it, care being taken that the conjunctiva is not incised. Thin slices of the tarsus are then removed with the scalpel from the cilia up to this tarsus incision so that a small furrow will be formed in this region. In cases in which the tarsus is much thickened and granular even above the line of tarsal plate incision, it is convenient to thin it out so much that one is leaving a step about 1 mm. deep. Five sutures are passed from the inferior lip of the wound to the anterior surface of the tarsal plate above the tarsal plate incision. Full curved needles should be used and the knot must be sufficiently taut to obtain a good position for the cilia. The superior lip of the flap is left undisturbed. In this way one gets a skin fold there with good cosmetic results.

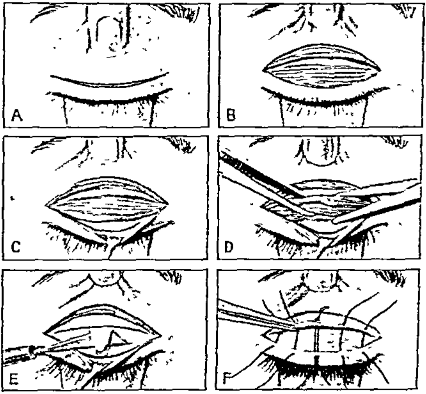


FIG 355 —Busacca's correction.

Busacca is emphatic in his insisting that the sutures should be placed close to the inferior lip of the flap and not to the cilia, and they can be removed ordinarily after forty-eight hours. At the completion of the operation, bichloride ointment is spread on the wound, a classical Barraquer dressing applied, and the eyes both bandaged for forty-eight hours.

Mucous membrane grafts, according to van Milligan's technique, are essential for the greater degrees of entropion. Ectropion of the upper lid of a moderate degree of severity may respond to buried sutures. The condition is rare, however. Ectropion of the lower lid (rather more common) may, with the upper lid, be corrected by Ziegler cautery punctures. Failing to correct with this will mean, however, some form of operation for inverting the lid margin and supporting the lid. A small pedicle flap from the outer temporal region turned upon itself and sutured into the lower lid

either under a bridge of skin directly according to the recommendation of Blasius and by the eversion of Hotz with a free skin graft is necessary. Entropion of the lower lid as the result of trachoma will usually need a mucous membrane graft into the cul-de-sac combined with a Panas or Graefe's skin resection of the lid surface or some similar procedure. Very moderate degrees of entropion of the lower lid, trachomatous in origin and oftentimes combined with an incomplete entropion or trichiasis of the upper lid will respond to an extensive canthoplasty (Vogt's technique). The incision is made at the external canthus, the external palpebral ligament is completely cut from its periosteal attachment, and three sutures are used to close the conjunctiva and skin. It is impossible to use mucous membrane grafts in trachoma at any time except in the cicatricial stages of the disease.

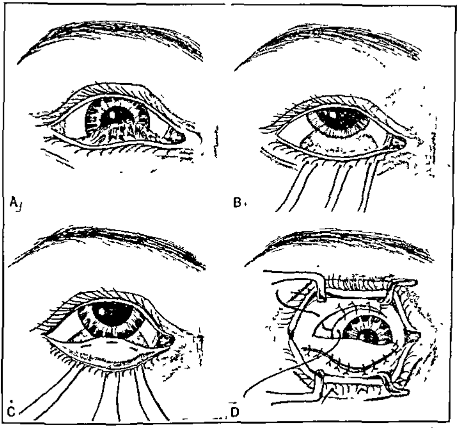


FIG. 356.—Conjunctival flap for symblepharon. *A*, before surgery; *B*, area denuded, cul-de-sac sutures in place, also in *C* and lid conjunctival surface folded into the cul-de-sac by the sutures; *D*, conjunctival flap in place.

CUL-DE-SAC RESTORATIONS (SYMBLEPHARON)

(SEE ALSO SECTION ON CONJUNCTIVAL SURGERY)

These conditions are always indications for the use of a mucous membrane, in all conditions wherein the eyeball is still intact and functioning as such. Figures 178, 179, and 180 illustrate such cases in the process of correction and photographs of essential points in the technique. They

should be carefully studied to observe the satisfactory manner in which the mucous membrane lies upon the cornea and is reflected into the cul-de-sac. The cicatrix responsible for the lost cul-de-sac must be opened and resected, releasing the eyeball from the symblepharon. The graft is then placed as described in the text accompanying Figure 180, and subsequently treated

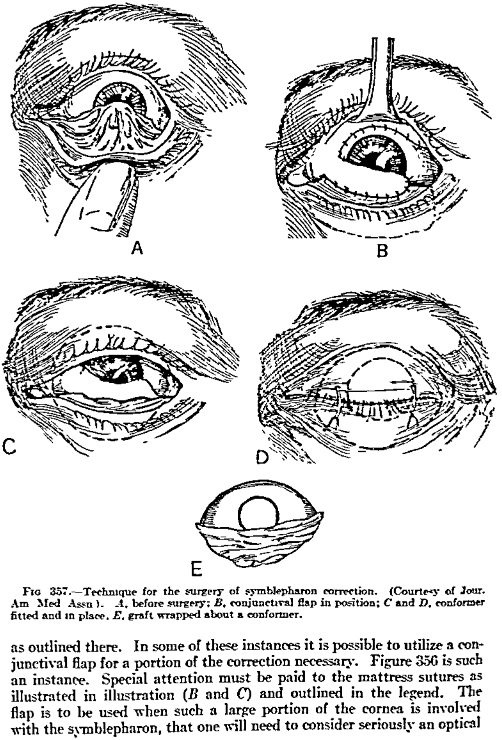


FIG 357.—Technique for the surgery of symblepharon correction. (Courtesy of Jour. Am Med Assn). *A*, before surgery; *B*, conjunctival flap in position; *C* and *D*, conformer fitted and in place. *E*, graft wrapped about a conformer.

as outlined there. In some of these instances it is possible to utilize a conjunctival flap for a portion of the correction necessary. Figure 356 is such an instance. Special attention must be paid to the mattress sutures as illustrated in illustration (*B* and *C*) and outlined in the legend. The flap is to be used when such a large portion of the cornea is involved with the symblepharon, that one will need to consider seriously an optical

iridectomy for the improvement of vision following the completion of the plastic correction. Mucous membrane, while satisfactory from a cosmetic standpoint as well as functional above reproach, remains quite opaque and does not offer any hope for visual acuity improvement. Hence,

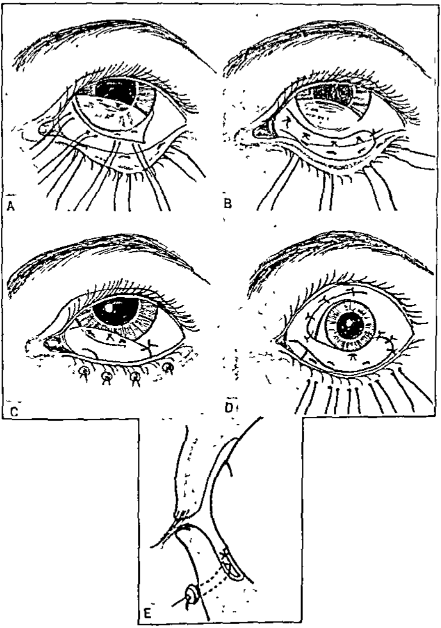
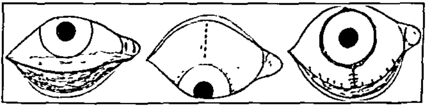


FIG. 358.—Disposal of mucous membrane graft on the cornea, *A* by dissection and suture, *B*, by flaps moved into the inferior cul-de-sac; *C* and *D*, similar distribution of mucous membrane from the limbus, *E*, diagrammatic side view of flap into the cul-de-sac

if the pupillary portion of the cornea is covered in the symblepharon adhesions, the conjunctiva must share in the correction. The symblepharon is first released and dissected free so that the lower cul-de-sac is without adhesions of cicatrices. A pedicle flap of conjunctiva is then cut from the

residual conjunctiva above the limbus (Fig. 357). This should be as broad as is necessary to cover the major portion of the cornea and as can be obtained from the conjunctival tissue there without the loss of the superior fornix. Before the flap is cut free, the entire conjunctiva of the superior fornix should be well undermined up to the upper border of the tarsal plate. This pedicle flap is then sutured across the cornea and the site from which it was taken closed subsequently. A mucous membrane graft is then to be wrapped over a glass or metal conformer, fitted into the inferior cul-de-sac and temporary intermarginal sutures placed to complete the operation. Here, as elsewhere with the use of mucous membrane, it must be carefully trimmed to a maximum stage of thinness. A pressure dressing is to be applied and not changed for five or six days. It may then be removed, the cul-de-sac gently irrigated with warm boric acid solution, the cornea carefully inspected through the hole in the conformer and, if everything is satisfactory, a second dressing applied for four additional days. The intermarginal sutures, which were originally tied in a bow knot, may be tied this time in a square knot and their ends cut in that; at the time of the next dressing they should be removed. If, after recovery, the conjunctival graft on the cornea is thick and unsightly, this can be readily corrected. The graft is lifted from the superficial corneal tissue by sharp dissection and the



A B C

Fig 359 —The correction of symblepharon (Arruga)

entire inferior cul-de-sac undermined. The edge of the graft is then sutured to the limbus by double-armed, very fine, silk sutures from the episcleral tissue through the graft, and this redundant graft tissue carried into a further formation of the cul-de-sac by mattress sutures passed through the lowermost portion of the inferior fornix, these to be carried out through the skin of the lid and tied over plates or buttons there. Figure 358 illustrates this plainly The denuded corneal area is then lightly tattooed, by the gold chloride method, to render the subsequent corneal scar as inconspicuous as is possible.

Arruga, in Figure 359, *A*, *B*, *C*, illustrated the correction of an inferior cul-de-sac symblepharon by the utilization of two large pedicle flaps from above the limbus to below the limbus. The two flaps are cut as outlined in *B*, and as they are moved downward the cornea moves upward into the vertical incision so that these two flaps can be coapted below the limbus to replace there an appreciable amount of bulbar conjunctiva. That which was present before the operation should have been transferred to the posterior surface of the lower lid itself, by mattress sutures, as just outlined.

In resection of the caruncle, when this is necessary, the dissection should go over on to the bulbar conjunctiva in a crescentic manner, the convexity of this crescent lying away from the inner angle, *i. e.*, the concavity embrac-

ing the caruncle. That portion of the caruncle tissue which must be removed is then removed with sharp dissection. The bulbar conjunctiva is undermined and the residual tissues at the inner canthus closed with sutures, after undermining into the superior and inferior cul-de-sacs. (See section on Conjunctival Surgery.)

Cul-de-sac reconstructions in the presence of old or recent enucleations are simply the problem of an incompletely contracted socket and are to be corrected according to the technique outlined for that. In such instances it is not necessary to wrap the entire mold with a graft if the superior cul-de-sac and fornix are still adequate.

Cul-de-sac restorations following enucleations may be corrected in many instances without a free skin graft if adequate conjunctiva is still present. Berens[1] called attention to this again recently. The scar tissue in the fundus of the orbit responsible for the inadequate cul-de-sac is resected subconjunctivally. A crescentic incision is made in the conjunctiva on the posterior wall of the fundus, and through this one can remove the cicatrix This crescentic conjunctiva incision is then closed. Mattress sutures are placed in a horizontal line in the conjunctiva at the lowest point on the cul-de-sac. Three to four are necessary. The needles are brought out through the skin, passing through the lid tissues, on the anterior surface at the inferior orbital margin; there they are tied over rubber pigs or through buttons upon the skin surface about 1 cm. below the level of the lid margin These sutures draw the conjunctiva downward firmly to the orbital margin restoring and maintaining a sufficient cul-de-sac. In resecting the cicatrix from behind it is wise, as Berens said "to use a scalpel, and carrying the incision down to the anterior surface of the inferior orbital margin along its entire extent keeping, however, close to the tissue of the lower lid" In regard to this technique, see also Figure 356 and those mattress sutures.

[1] Am Jour Ophth, Ser 3, vol. 26, No 2, February, 1943

CHAPTER XIII

SURGICAL CONDITIONS OF THE LIDS.—Concluded.

Cicatricial Incisura of the Lids. Forms of Blepharoplasty for Lid Reconstructions.

Most of these cases are the result of window glass cuts in automobile accidents and of knife and razor cuts while fighting. Figure 360 is such an instance. The inner canthus is torn loose, the canaliculus has been lost and there is more or less ectropion accompanying the case. Again here, as

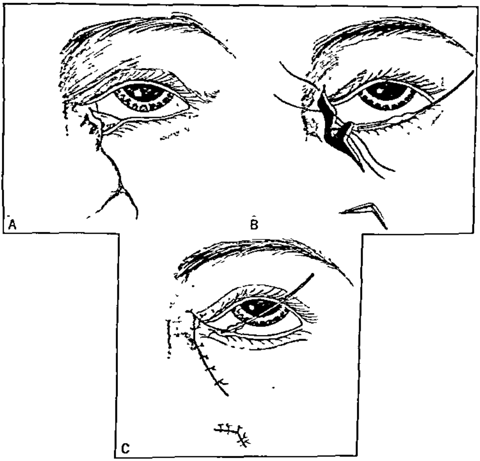


Fig. 360.—Cicatricial incisura from windshield cut. Note the method of reëstablishing drainage through the canaliculus. *A*, original injury; *B*, incision and suture; *C*, probe through punctum and into the lacrimal sac.

in many other instances, detailed preoperative study of the case is necessary to decide upon the therapy one is to utilize. The scar must certainly be resected and the inner angle of the lid moved upward into a slightly overcorrected position. After the resection of the scar, as outlined in *B*, one can see readily the position to which the inner angle of the lower lid

now mobilized must be elevated. The importance lies *in placing the* sutures for this elevation and correction into the fixed lip of the scar tissue resection wound while the other one is placed at a considerably lower level, *obliquely downwards*, in the movable undermined lip of the lid side of the *scar tissue resection wound.*

In these instances illustrated, before the sutures are placed, a probe is to be passed through the punctum across the operative wound and into the lacrimal sac through a hole punched in there, and a No. 1 or 2 silver lacrimal probe passed from the punctum into the lacrimal-nasal duct. This is to be retained for two weeks to two months to obtain complete recovery from the epiphora and functioning of the canaliculus. *C* is the end-result at the *time of the completion of the operation and just before the postoperative* dressing was applied.

CICATRICIAL INCISURA OF THE LIDS

Cicatricial incisura may be accompanied by ectropion of the upper lid and entropion of the lower. The cicatrix, if carefully resected, however, and as carefully resutured, should correct these readily. Figure 361 is such an instance. The case resulted from the patient falling into the blade of a harvesting machine; *A* shows the defect and *B* the end-result. Figure 362 is an outstanding example of the correction of a cicatricial incisura by scar

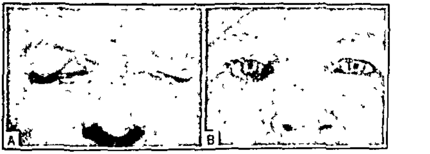


FIG. 361.—Cicatricial incisura with ectropion. *A*, before surgery. *B*, after scar resection.

resection and suture, paying careful attention to the position of the correcting flaps. A long and deep cicatrix dragged the lower lid down and out with a marked resulting deformity. The accident resulted from an aeroplane propeller. *A* of Figure 362 shows the residuals present, the scar resection necessary for the correction, and the line of sutures as planned. In Figure 363, *B*, the flaps *a* and *b* as outlined, should raise the upper lid *from its position of marked deformity and* at the same time furnish sufficient soft tissue to correct the obliquity of the palpebral fissure resulting from the drag of the cicatrix. *B* of Figure 362 shows the case immediately before the removal of the operative sutures, and *D with an ocular prosthesis in* position twelve months later. *C* shows the suture line resulting from a Snellen operation for some entropion which remained in the lower lid. This same entropion can be seen in the preceding photographs. In closing these incisuræ at the inner canthus, the suture line should be deviated from the vertical as much as is possible. Those which were originally vertical cannot be changed to any great extent, but the others can be shifted. Similar

arrangements may be worked out for all such cases, as in Figure 364. In these, one must be certain that notching of the margin will not remain after healing. Attention has been called to this before. In delayed surgery,

FIG 362 —Cicatricial incisura at angle, *C* shows the suture line from a Snellen entropion operation necessary as the final step in this case to correct the entropion so evident in *B*.

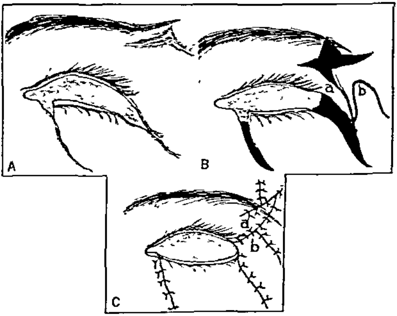


FIG 363 —*The scar tissue resection and suture correction for the case in Figure 362.*

as with this, subcutaneous sutures of catgut for the orbicularis, and silk sutures for the skin, should be combined with the marginal flaps.

It is rather likely that a great majority of these cicatricial notches of the lid could be prevented if more careful surgery were carried out at the

time of the original closure of the lid following the original accident. Figure 365, *A* and *B*, is such an example. The patient, following an automobile accident, was so seriously ill that little attention was paid to the ocular defects. Following her recovery, however, the cul-de-sac, the sclera, and the upper lid were firmly adherent one to the other with a most unpleasant cicatrix. The eye was in phthisis bulbi. The scar resection and suture, following an enucleation with an implant into Tenon's capsule, and a skin graft into the socket for the reëstablishment of the superior cul-de-sac, resulted in a very satisfactory cosmetic result. *C* of Figure 365 is this end-result after her third operation. With the exception of the free skin graft into the superior cul-de-sac for the reformation of this all surgery was a matter of scar resection and resuture of the lids in layers, muscle as well as skin.

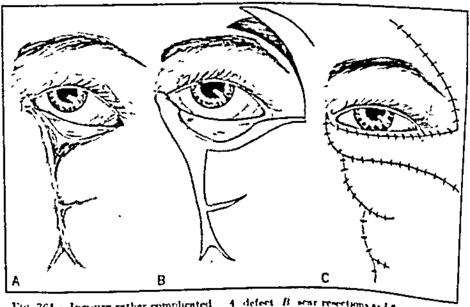


FIG. 364.—Incisura rather complicated. *A*, defect. *B*, scar resections and flaps outlined. *C*, suture lines illustrated.

arrangements may be worked out for all such cases, as in Figure 364. In these, one must be certain that notching of the margin will not remain after healing. Attention has been called to this before. In delayed surgery,

FIG 362 —Cicatricial incisura at angle; *C* shows the suture line from a Snellen entropion operation necessary as the final step in this case to correct the entropion so evident in *B*.

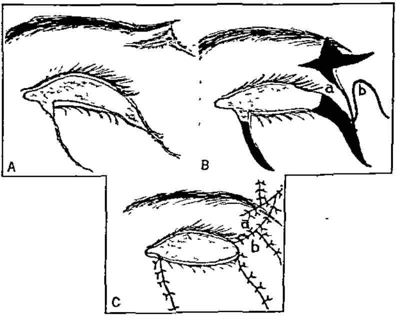


FIG 363 —The scar tissue resection and suture correction for the case in Figure 362

as with this, subcutaneous sutures of catgut for the orbicularis, and silk sutures for the skin, should be combined with the marginal flaps.

It is rather likely that a great majority of these cicatricial notches of the lid could be prevented if more careful surgery were carried out at the

;nple matter to wipe that off with the actual cautery. These tiny flaps, they are formed, are of the lid margin and away from the line of lashes. ıey need to be only 1 mm. in length. If the tarsal plate above them is mly and carefully approximated they will turn outward and downward themselves.

Following the tarsus-conjunctiva suture the orbicularis fibers should be und and sutured together with 6-0 catgut interrupted sutures. The skin en is to be closed in a third skin-layer line of sutures These are to be of ıck silk. Prior to the closure of the skin line a small portion of skin ould be removed from the major lip of the intact lid so that as the skin rface itself is closed over its suture line will be offset from the suture line the orbicularis fibers, and this in turn will be offset from the line of rsal-conjunctival sutures. It is always well to prevent incision lines which e perpendicular to a lid margin. Terracing and Z plastics will be of great lue in obviating this undesirable feature.

LID RECONSTRUCTION—BLEPHAROPLASTY

In reconstructing the upper and lower lids one must consider the follow- subdivisions; upper and lower lid reconstructions with adequate con- nctiva; those cases with inadequate conjunctiva; the simultaneous cor- ction of both upper and lower lids; and a complete symblepharon The rest defect is the simultaneous loss of both upper and lower lids.

Fortunately the upper lid seems to escape total destruction in most stances. The next most frequent defects are the cases with both lids paired but with usable remains still present No case has ever presented elf to the author in which the upper lid alone was involved and completely stroyed. There seem to be so many possibilities for this to occur through ıuma or because of possible necessary operative measures with postoper- ive deformity that one may almost consider their rarity "the accident of accident." The comple loss of a lower lid is not uncommon, caused her by trauma ratively. But there are so many possible formities of the ne, or of the upper lid with canthal deform- es, that one is ndo soepe perit occaso" to write as above, ncerning upper

The opera w if a fair amount of time is used in the

small but cleanly sectioned, so that when the last suture has been placed closest to the lid margin these will pout out, one against the other very slightly. They will prevent a subsequent notching of the lid margin, and if a little nubbin of tissue does remain there after healing has occurred it is a

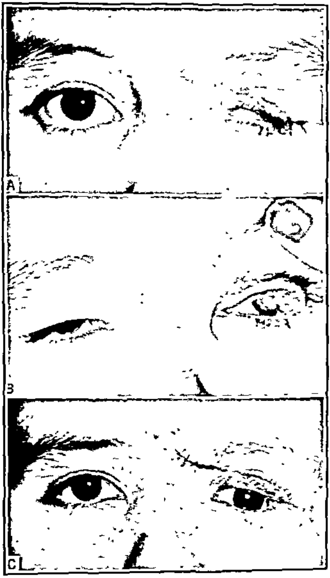


FIG. 365 A.

FIG. 365 B.

FIG. 365.—A, Cicatricial notching of lid; B, The same case, one year later.

depends upon the amount of conjunctival tissue remaining. Therefore for the sake of convenience we will divide these cases of lid reconstruction into two classes, the first in which there is sufficient conjunctiva, and the second class in which this, as well as the epithelial surface of the lid or lids, is more or less completely lost.

Upper Lid Reconstruction With Sufficient Conjunctiva.—If the conjunctiva is still present in ample amounts the problem is much simplified. Figure 366 illustrates a simple method for lid reconstruction with a pedicle flap from the edge of a scar on the face, but in these cases there is sufficient conjunctiva in the cul-de-sac so that one may use the method without complications. There is no danger of other lid deformities, as of entropion, developing in such cases. It is the simplest procedure possible (Fig. 367). If one wishes, the graft flap can be taken from any position close to the lid, from the cheek below the lower lid and over the malar bone, from the brow, or from an area in the neck, bringing the pedicle of the flap upward, tubulated or non-tubulated. The pedicle may be resected at some later date and returned to its original site or discarded entirely.

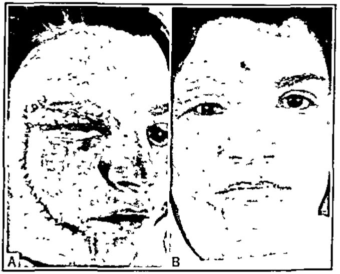


FIG. 366 —Simple pedicle flap, this combined with a scar resection from the face; *A*, flap in position, *B*, completed result.

This last flap method, with relationship to the upper lid, has many good reasons for its use. The use of a pedunculated non-tubulated flap from the skin of the neck as suggested by Snydacker is oftentimes satisfactory. There is no additional scarring of the face, and the pedicles can be discarded without serious loss or utilized in many different ways, depending upon the case under correction. The advantages of the Snydacker method[1] are: ease of execution, production of less deformity than if the flaps were taken from about the face, and if the flaps were to slough far less damage would occur than if the flaps had been taken from the skin of the face. Also, the loose skin of the neck is better adapted for plastic purposes on the eyelids than the thicker skin of the face or the forehead. Le Maitre, on the other hand, states that the classical blepharoplastic repair is that obtained

[1] Monatsbl. f Augenh., January, 1907.

through the use of horizontal forehead flaps with the pedicle lying externally. He occasionally uses this same type of flap in certain rhinoplastic operations. In discussing rhinoplastic operations he claims the following advantages for forehead flaps. They are also applicable to ophthalmic surgery, namely, union by first intention, and better vitality of the graft flap because of its position.

The author has, on several occasions, used the Snydacker method for necessary upper lid correction, and in one case at the time of the second operation for the disposal of the pedicle, utilized the pedicle for a further necessary repair of the lower lid. The period between the first two operations was four weeks, and the pedicle from the upper to the lower lid, which was then loop-shaped, was completely resected four weeks later. Blair, in 1921, called attention to the delayed transfer of long pedicle flaps. This procedure is a valuable addition to the free utilization of skin from distant areas, as from the neck, or from the chest, in extensive plastic work upon the face. But it is seldom that the ophthalmic surgeon is called upon to correct defects sufficiently extensive to make this procedure necessary. *It is well to bear it in mind if occasion should arise in which the method would be practical.*

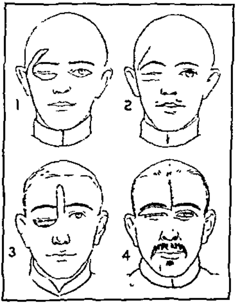


FIG 367 —Palpebral autoplasty with flaps (Courtesy of P Blakiston's Son & Co)

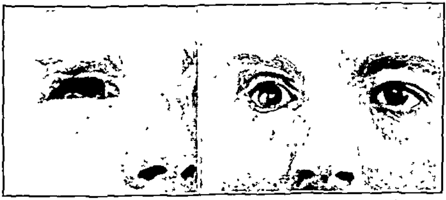


FIG 368 —Free skin outlay for upper lid reconstruction (Courtesy of Oxford Medical *Publications.*)

In pedicle flap reconstruction all the dissections must be well undermined with complete release and excision of the scar tissue present. The initial incisions are made boldly but smoothly to *minimize the amount of later* scarring. As soon as the dissection has advanced to a sufficient amount, so that the lid margin may fall to its proper normal level, intermarginal

sutures must be inserted for the period of healing. As the lid margin is moved downward, the wound in the upper lid will gape a certain amount. This widening of the wound will allow the operator to undermine and release any attached or adherent conjunctiva which is limiting the movements of the lids. This also might cause it to undergo a later contraction.

The operator should plan rather carefully the direction and the course of the pedicle of the flap, even if it is to be tubulated, to prevent kinking at the base of the pedicle. The use of triangles will allow a greater amplitude of movement in the flap. It does not increase the amount of scar.

If a flap from the neck is to be used the pedicle must start immediately beneath the angle of the mandible and extend toward the clavicle. The pedicle must be at least 1 inch wide and may or may not be tubulated at the discretion of the operator, depending upon whether or not this pedicle is to be used subsequently for another purpose. If it is to be tubulated, the pedicle should be cut at least ½ inch wider. The dissection in the neck can be closed without difficulty with an intradermic dermol suture. The properly-shaped apex of the flap is sutured in the position prepared for its reception in the dissection at the defect. Ten days later when the pedicle attachment is to be resected, and resutured, a very slight amount of dissection will be sufficient to render this area smooth and satisfactory. Both upper and lower lids can be corrected at the same time. It is necessary to split the apex of the flap into halves, one for the upper lid, and the other for the lower lid repair. It might even be possible to use a third subdivision for any necessary repair of a socket defect.

Reviewing the methods at our command for the repair of upper lid deformities in which the case is not complicated by conjunctival limitation, we find the following available—first, simple scar excision with the replacement of the soft tissues to a normal position; second, the use of pedicle flaps; third, the use of free skin grafts placed directly into a wound resulting from dissection sufficient to return the lid margin to its normal position; and, fourth, the use of Ollier-Thiersch grafts over a mold as an outlay graft. See Figure 368 illustrating Gillies' technique for an upper lid repair, which has been covered. Any necessary repair to the upper lid line of lashes can be accomplished by one of the methods already explained.

Lower Lid Reconstruction With an Adequate Conjunctival Cul-de-sac.—The technique and methods for the repair and reconstruction of these are exactly the same as were used for the upper lid repairs. In cases where an enucleation had been done, a cul-de-sac sufficiently deep to allow the satisfactory fitting of an ocular prosthesis without the constant danger of this prosthesis extruding itself is usually sufficient. Much can be done in the manufacture of artificial eyes by placing the cornea low down on the shell so that the presence of a shallow cul-de-sac from a narrow lower lid will be masked. In those cases where the globe is still in place and of a normal appearance, the lid margin should be, when completed, at the same level as upon the opposite eye. With the patient looking straight ahead into infinity this is seldom more than 1 mm. below the level of the limbus.

A lower lid deformity is more readily corrected by free dermo-epidermal grafts than is the same deformity in the upper lid. The demand for free movement in the upper lid is not so important in the lower lid. This, perhaps, is the real reason why satisfactory cosmetic results are more readily obtained by the use of these grafts in the lower lid defects. The grafts are

most satisfactory as full thickness grafts (dermo-epidermic) when taken from a normal upper lid, or from behind the lobe of the ear. A razor cut epidermal graft may be used also, but the full thickness grafts are very satisfactory here. Dissection to obtain the release of the adherent, misplaced remains of the lid margin is the first step, an intermarginal suture of the lid is next, and the placement of the correcting graft completes the operation. Dependence should be placed upon a pressure bandage rather than upon a large number of sutures to hold a dermo-epidermic graft in place with accurate and close approximation to the underlying tissues. The pressure exerted by the dressing not only accomplishes this, but also decreases bleeding and serous oozing, both of which are inimical to a good result.

Ollier-Thiersch grafts over a mold of dental wax, according to the method of Gillies, are also satisfactory in cases where the scar can be completely *removed, the same as in reconstruction of the upper lid. This method,* however, is more applicable to defects of the lid than to the reconstruc*tion of a more or less completely lost lower lid. If this method, how*ever, is utilized, a secondary operation, that of a tarsorrhaphy, will be needed to fix the outer and inner angles of the newly formed lid, because of the slightly overhanging shelf of the upper portion of the new lid; raising it to a proper level and thus correcting any postoperative ectropion present. This is not a difficult matter.

In the presence of scar tissue of any degree which cannot be completely removed Ollier-Thiersch grafts are impracticable, because of their thinness. They are without any supportive substructure, and will, even after a complete take, contract rapidly to a total failure. This means that such grafts are not to be used if there is any danger of continued contraction of either the underlying or the surrounding tissues. These grafts are therefore applicable only in cases of deformities following superficial burns or in clean, non-contracted postoperative deformities such as would occur in the removal of superficial malignancy of the lower lid. Under conditions other than these, pedicle flaps from the face, forehead, or neck, must be used as the remedial agent. The bases of the pedicles may be arranged to lie either in the temporal region, *at the bridge of the nose, or behind the angle of the* jaw. See Figure 250, *A* and *B*, and Figure 369. The dissection for the *preparation of the flap is the same as if a dermo-epidermic graft were to be used. The lid margins, when sutured in a temporary tarsorrhaphy*, will allow *quite* extensive subconjunctival dissection of the inferior cul-de-sac through the wound, and thus guard against any later entropion, due to conjunctival tension with epithelial relaxation from an excess of skin in the newly formed lower lid. If the flap is taken from the neck the pedicle may be later discarded, or the pedicle later returned with the remainder of the flap to its original position. The incisions must be neat and smoothly made, all hæmorrhage absolutely stopped, the sutures mattressed with great care, and the postoperative dressing sufficient to hold the flap in place without creeping. If the hair line is not intact, a graft from the normal upper eyelid bearing hairs, or one from the scalp, *will* complete the lid restoration. Snydacker's method is also quite applicable to the correction of *lower lid conditions.*

The operator must be prepared at all times to correlate certain known *methods, and the methods used* [illegible]onally by some person in the [illegible]

ment of an unusual case, with his own ingenuity, so that the case under his consideration will be handled to its best advantage. The few definite, but rigid, inflexible rules connected with plastic surgery can be adhered to without difficulty.

FIG. 369.—*A*, case of a lower lid defect; *B*, non-tubulated pedicle flap from forehead for its correction, *C*, case completed. (By permission of Dr. Axenfeld.)

Upper Lid Repairs and Reconstruction With an Inadequate Amount of Conjunctiva.—The correction of such defects frequently amounts to a combination of socket reconstruction with blepharoplasty. For a case in which nothing remains of the upper lid and the cul-de-sac save, perhaps, a ridge of tissue attached to the upper portion of the bony orbit, an operation inspired by one of the methods of Morax is applicable. This should not be attempted if any remains of the hair line are present and certainly not if the oculus bulbi is still in place. Fortunately, or unfortunately, depending upon the viewpoint, these upper lid deformities of any marked gravity are seldom found in a case where the globe of the eye is still normally present.

The epithelial base of the lid remnant is released by a crescentic incision, and then by careful dissection it is gradually moved downward until the epithelial and conjunctival surfaces are upon the same plane, forming a flap, one continuous with the other, and in length equal to the amount of the two surfaces. The dissection at the edge where the epithelial surface passes over into the conjunctival surface will have a fair amount of scar tissue present. This must be thinned out and removed without perforating the flaps. Blunt scissors will lessen the chance of doing this. As soon as the entire dissection is completed, a mold is placed into the socket to

simulate the later prosthesis, thus obtaining the level and normal anterior convexity of the lid and to furnish a support for the dressing. As soon as the mold is in position the edges of the flap reflected downwards are sutured into linear incisions in the skin surface, the first in the position of the normal outer canthus immediately above and within the rim of the bony orbit, and the second at the inner canthus at the same level as the punctum, curving slightly upward and outward following the curve of the bony orbit. This reflected epithelial flap is sutured to the posterior lip of these incisions with dermol interdermic sutures to facilitate their later removal. The anterior lips of these incisions furnish the edges to which the sutures are placed if a pedicle flap is used to cover the operative defect.

FIG. 370.—Simultaneous correction of upper lid, lower lid and inferior cul-de-sac

From this point the operation depends upon whether the deformity includes both lids or one lid alone. If the lower lid is normal, intermarginal adhesions of this reflected epithelium should be arranged between the flap and the other lid. If one is planning to cover the dissection defect with a pedicle flap, these adhesions are not necessary, a simple temporary tarsorrhaphy is sufficient, otherwise actual tissue adhesions must be arranged. This is done by notching the margin of the lower lid and suturing the deflected flap from above to these lower lid notches with silk mattress or intermarginal dermol sutures. A pedicle flap from the neck, from the forehead, or from the temporal region, can be moved into position to cover the raw surface formed by the dissection. If a flap is used, the sutures should be carefully placed at the junction of the reflected surface and the inferior edge of the flap. A flap from the forehead is the least satisfactory, one from the neck being better.

Figure 370 illustrates a case of simultaneous lid and cul-de-sac reconstruction. The first of the three illustrations shows the fixed inadequate

lids with very shallow cul-de-sacs barely able to hold an artificial eye. The first operation was the reconstruction of the inferior cul-de-sac to permit the proper seating for a prosthesis. In the second operation the upper lid was incised along the orbito-palpebral fold and opened upon itself so that the anterior skin surface of the lid was reflected backward and formed the new posterior surface of the upper lid. A conformer was placed in the cul-de-sac, the new margin of the upper lid attached temporarily to the lower lid, and the bared area formed by the reflection of the skin surface (of the upper lid downward) was covered with a free-skin razor-cut graft. The resected hinge was very firmly and securely attached to the internal and external canthal angles so there would be no notching nor incisuræ there in the new lid margin. As soon as this graft had taken, a piece of ear cartilage was resected the shape and the size of the normal tarsal plate, and this placed between the new posterior surface of the lid formed by the former anterior surface and the skin graft. Figure 371 illustrates the technique. The third illustration shows the very satisfactory result which *has been obtained thereby; in fact, now redundant lid tissue is actually* present which may need some resection.

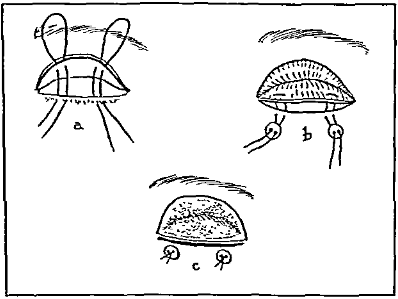


FIG 371 —Technique for the upper lid repair.

Dermo-epidermic grafts, if used, have a slight advantage over Ollier-Thiersch grafts in that they are more substantial. The defect, however, formed by the dissection is rather large and for that reason the chances for a completely successful take in the use of dermo-epidermic or epidermic grafts are less than if a pedicle flap graft were used. The defect will be too large for the use of a graft from the opposite lid. If a true skin or dermo-epidermic graft is used, care must be taken to clip from its under surface every bit of subcutaneous tissue. Attention to this will be repaid by a thinner lid as well as by greater viability in the graft. Sufficient sutures of fine black silk, waxed or paraffinized, may be used to hold the graft in position. When the bandage is applied, a thin layer of paraffinized

gauze must be molded so that the graft fits closely over the curvatures of the mold in the socket and thus follows the normal curves of the upper lid. If accurate and close approximation of this graft is not obtained with the surfaces immediately beneath it, the graft will not survive. Folded gauzes, 2 x 2 inches, or small gauze fluffs can be placed above the layer of tulle or paraffinized gauze to fill out the depression and allow the bandage to exert the proper pressure.

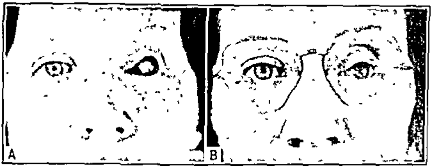


FIG 372 —*A* and *B*, graft into socket and simultaneous free skin graft into defect upon outer surface of lid

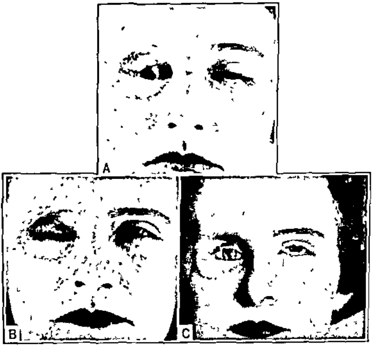


FIG. 373 —Contracted socket, scar about orbit; defect with notching of upper lid Halving operation of the upper lid defect, correction of contracted socket with a simultaneous *free skin graft in the lid*, fascia graft and completed result with prosthesis after socket graft

If an Ollier-Thiersch graft is used to cover the dissection defect, the technique is the same as has been previously explained Later, after complete recovery has taken place, but before the intermarginal adhesions are cut, the line of lashes may be restored by a *free graft from the upper lid of*

the opposite eye. See Figures 372 and 373 which were cases corrected in this manner.

In the section on the general technique of plastic surgery other valuable procedures were detailed, applicable here.

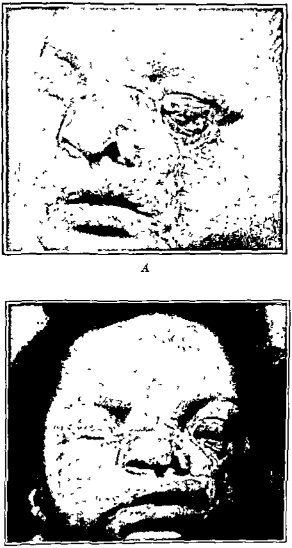
Raphael Kaz reported an operation quite similar to one the author devised for the lower lid. He cuts a supra-orbital flap with the pedicle at the temporal region and includes the upper edge of the eyebrow in the lower edge of the flap so that when the flap is swung downward to replace the absent lid the hairs will act as eyelashes. A smaller flap from the temporal region is turned under to form the new conjunctival or posterior surface of the lid. The supra-orbital flap forms the anterior surface of the lid. By the turning under of the temporal flap the lid is given its normal rounded appearance.

FIG 374 —*A*, original defect (see also Figure 183). *B*, graft correction of lower lid, and following cul-de-sac repair and with Hess sutures in place for the ptosis; *C*, with prosthesis in place at the time of discharge from the hospital

A third manner in which the correcting operation may be carried out is the use of a pedicle flap for the relief of the epithelial deficiency, combined with an Ollier-Thiersch graft over a mold of dental compound to repair the superior conjunctival fornix. This may be done in two stages. (Figs. 183 and 374). The operation is only applicable when the eyeball has been enucleated. The adherent lid margin remaining is released and lowered to its normal closure position, and there sutured temporarily to the margin of the lower lid. To accomplish this it may be necessary to undermine widely the remaining superior fornix from its adherence to the bony orbit. This will allow a later extensive entropion to develop. Sufficient width in the pedicle flap must be used, however, to bring the lid margin to its proper level. The entropion will be corrected when the superior fornix is repaired. Cotton balls, impregnated with sterile petroleum jelly, will be sufficient to place in the contracted socket after the flap is sutured in position for the very moderate amount of pressure applied later by the dressing. Neither Ollier-Thiersch nor dermo-epidermic grafts for the outer surface of the lid lend themselves as well to this method. As soon as the flap has healed in ten days or two weeks, the fornix may be reconstructed. The technique previously explained in the use of Ollier-Thiersch gr[illegible], and further c[illegible] sidered under socket restorations is the method use[illegible] It is not nec[illegible] that the entire mold be covered with a graft if t[illegible] is alone at but it is safe, even though a portion of the graft is [illegible]iberately v[illegible]

and it is seldom that the condition of the lower fornix is entirely satisfactory. At a later date any necessary repair of the line of lashes is easily accomplished.

Occasionally a lid reconstruction must also be accompanied by extensive scar tissue resection as a result of contiguous cicatrices. Figure 375 is such an instance wherein a massive keloid, with contracting cicatrices, was



A

B

FIG 375.—Keloid with ectropion.

accompanied by a complete ectropion as a result of the loss of the entire lid surface, of the lower lid, and of the face obliquely down to the angle of the mouth. After the resection of all cicatrix and the formation of intermarginal adhesions from the conjunctival surface of the lower lid into the lid margin of the upper lid, a defect remained which had to be filled in with a very large free skin graft. In such instances the graft should be sutured through the graft surface to the edges of t[illegible] area with black [illegible]

sutures. The entire surface of the graft is to be larger by at least 1 cm. than the dissection defect to be filled in. The sutures, as they are placed, go through the surface of the graft, picking up the edges of the dissection defect, and are tied upon the surface of the graft, being cut fairly long. Accurate approximation is necessary but a small number of sutures is needed. The purpose is to prevent the graft from becoming displaced as a result of postoperative uneasiness and unrest. Before the graft has been sutured into place a mold is formed of dental stent sufficient to cover the entire area of the dissection defect. This is formed upon the face when semi-solid, cooled with ice water while in position, then after the graft has been sutured into place the mold, first anointed with petroleum jelly, is placed directly over the large grafts and bandaged into position with adequate pressure.

When the eyeball is still in position and is a healthy and normal eyeball, an entirely different problem is at hand. One dare not arrange the correction so that epithelium is in contact with the lid surface. A mucous membrane graft must be buried under the skin of the forehead above the eyebrow so that when the flap is brought down subsequently, the posterior or mucous membrane surface will cover the entire lid defect. The forehead is incised for a pocket of the proper size. A large mucous membrane graft is resected and wrapped about a thin metal plate or dental stent. This is placed into the pocket formed beneath the skin, the incision line sutured, and a pressure dressing applied. The case is first dressed at the end of six days and daily thereafter. Two weeks after the first operation, the remnants of the lid margin are incised at the conjunctiva-skin junction and two separate lamellæ formed by sharp dissection. A row of six silk sutures is placed in the conjunctival lips of the wound, and the ends of these sutures drawn to the side for the time being. The pocket formed above the eyebrow is cut free as a pedicle flap, its pedicle at the outer angle. This is moved down over the palpebral defect and the conjunctiva of the lid remnants sutured to the mucous membrane on the posterior surface of this flap by means of the sutures already introduced. Both ends of these sutures are then brought through the skin surfaces of the flap, tied, and their ends cut short. The apex of the pedicle of the flap is trimmed to fit neatly into the inner canthal angle (or defect) and is sutured there, mucous membrane to conjunctiva, and skin to skin. The lid margin of the lower lid is now incised with three short incisions; the lower lip of the flap trimmed to a proper width, and the mucous membrane surface of the flap sutured to the posterior conjunctival lip of the three incisions made on the lower lid. The ends of these sutures are also brought out through the epithelial surface of the flap. Before these are tied, however, the epithelial surface and the mucous membrane surface at the lower edge of the flap are closed by a necessary number of fine black silk sutures. (The removal of the flap, from above the forehead, as well as the subsequent trimming of the flap for proper width, has permitted these two surfaces to separate for the length of the flap itself.) A piece of oiled silk is then placed beneath the pedicle of the flap from the external commissure to the base of the flap. An area of mucous membrane still remaining on the forehead is now removed, the entire region cleansed, and this covered with a razor cut epidermal graft. The gaping skin edges near the base of the pedicle of the flap are pulled together, in part, with a few sutures. This is to be reopened subse-

quently when the pedicle of the flap is returned to the site from which it came. A piece of oiled silk is placed over the two lids, and a dressing with rather moderate pressure is applied. In applying this dressing, rolls of dry gauze should be placed upon each side of the base of the nutrient blood supply from the pedicle of the flap to the correcting apex. Both eyes are to be bandaged. The first dressing is to be done *on the fifth day*. Many of the sutures are to be removed at this time, though the intermarginal *sutures should not be removed until the eighth day*. On the twelfth day, under ordinary circumstances, the pedicle of the flap at the outer commissure may be cut free, turned backwards upon itself, and any excess

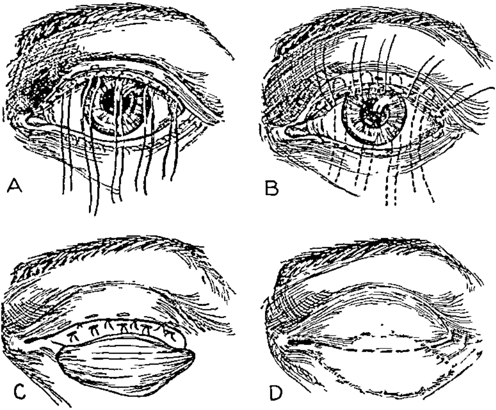


FIG. 376.—*Axenfeld's technique for upper lid reconstruction Photographs in Figure 377* show lids adherent for later section and palpebral fissure formed to show extent of closure possible. (Axenfeld, Barth, Leipzig, 1922.)

mucous membrane removed. The skin is now reopened at the site from which the pedicle originally came and this returned to its former position. At the same time the commissure is trimmed up and dressed with sufficient sutures. *The lid margins are to remain intermarginally adherent for about six weeks.* At that time a free skin graft may be taken from the eyebrow on that side immediately *beneath the eyebrow for the reconstruction of* the lashes according to the technique already covered and illustrated.

Another form of upper lid reconstruction, with inadequate conjunctiva, has been given to us by Axenfeld;[1] Figure 376 is a copy of his original

[1] Axenfeld, Prof. Dr. Theodor, Augenheilkunde, Handb. d ärztlichen Erfahrungen, Verlag von Johann Ambrosius Barth, Leipzig, p 488, 1922.

illustrations to show the technique. The margin of the upper lid remnants is resected so that it presents a raw surface from canthus to canthus. Six double-armed sutures are then mattressed through the lid from without inward so that these sutures emerge under the lid margin. The entire hair line of the lower lid is then cleanly removed, and these sutures from the upper lid passed through the conjunctiva and skin lamellæ thus formed. Before they can be tied, however, the skin surface of the lower lid must be incised, and through this incision the conjunctiva of the lower lid undermined to a certain extent so that the lid can be moved up and attached to the remains of the upper lid. The six sutures are now tied and any necessary additional skin surface suture introduced. The incision made in the lower lid skin surface will gape rather widely. This is to be covered with a free skin razor cut graft and the entire eye dressed with a pressure dressing. Ten days later the dressing may be removed, and after two weeks wholly discarded. There will be a slight opening still remaining at the inner or

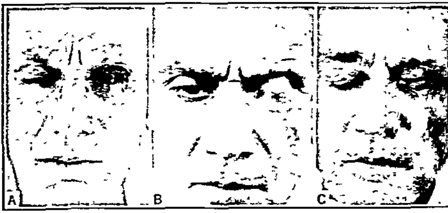


FIG. 377.—*A*, gross upper lid defect. *B*, lids sutured together with permanent complete marginal tarsorrhaphy with skin graft into the lower lid, prior to the formation of new palpebral fissure; *C*, new palpebral fissure showing closure possible at the time of discharge from the hospital. Axenfeld's technique followed throughout. (Notice the curve of the completed intermarginal tarsorrhaphy.) (Patient had 6/9 vision in O.S.)

outer canthal angles. Warm boric acid irrigation of the cul-de-sac can be carried out through this, using a small blunt lacrimal sac needle attached to a proper syringe. The lid margins are permitted to remain adherent for several months. The new palpebral fissure can then be formed by making a horizontal incision at the position where the palpebral fissure should lie. The incision is to pass from internal to external canthal angles. The anterior and posterior surface of the lids should be very carefully united with many fine black silk sutures at this time, the same as one would do with an ankyloblepharon. Figure 377 illustrates such a case corrected with this technique. Axenfeld recommends tattooing these lid margins with tiny dots of black India ink to simulate lashes. It seems to the author that here also a more satisfactory procedure would be the transplantation of an upper lid eyebrow graft from the opposite eye for the reconstruction of the lashes, one especially to be placed above the anticipated line of incision for opening the palpebral fissure, the other one separately below this. Both grafts should have the edge, with the eyebrow hairs, in apposi-

tion. After these have healed satisfactority the palpebral fissure can be opened between them.

Lower Lid Reconstruction With an Inadequate Conjunctival Cul-de-sac.—Lower lid reconstructions in which the same complication exists, that is, the loss of the inferior fornix due to an inadequate amount of conjunctiva, can be corrected according to the same methods outlined for the upper lid. The manner of covering the operative defect is also the same as mentioned before in reference to lower lid reconstruction (Fig. 378).

A pedicle flap is the best of the three methods, *i. e.*, Ollier-Thiersch grafts, dermo-epidermic grafts and pedicle flaps. A flap taken from the neck can be used as well.

FIG. 378.—*A* and *B*, Ollier-Thiersch grafts into socket and into lower lid. *C* and *D*, Ollier-Thiersch graft into socket, scar tissue resection and dermo-epidermic graft into skin surface. *A* and *B*, the lower lid; *C* and *D*, both lids.

Under the section of pedicle flaps, a rather complex operation was explained in which a pedicle flap from the forehead was carried down with a tubulated pedicle, turned upon itself, and used to form the posterior surface of a new lid, the anterior or epidermic surface being formed by a sliding flap from the skin over the zygomatic malar junction, from the skin over the cheek, or from the skin of the neck in the form of a long pedicle flap. The last position is perhaps the best, though the most difficult of the three. A point or two is worth repeating here in relation to the flap from the forehead. If the eyeball is still present, the surface of this flap must be free from hair follicles; second, the incision line on the forehead, after closure of the region from which the flap was raised, can be made practically invisible by a careful intradermic or subcuticular suture and this removed at an early date after the operation, say four days; and last, the manner of handling the pedicle. When the flap has been turned back, all subcutaneous tissue must be carefully removed from that portion of the flap which is to enter into the formation of the lid. All of the other parts of the flap

should be left untrimmed. This will make a thicker, more resistant tubule, and thus carry to the head of the flap a more abundant blood supply. The flap is to be cut so that the root of the pedicle is curved slightly upward and slightly wider than that portion used for the lid. This will give a better angle to the base or attachment of the pedicle and a thicker tubule. Later, when this pedicle is resected and discarded, the incision will curve upward, but the amount of tissue removed will not change the amount of scar. When the bandage is applied, the surgeon should be careful that the nourishment of the tubule and of the head of the flap is not interfered with through pressure. This is easily prevented by placing two small gauze rolls, covered with oiled silk, on either side of the tubed pedicle, both somewhat thicker and higher than the level of the tube itself. A third, though smaller roll can be placed under the tube to fill in the small triangular space beneath the tube, and at the same time give it a steady support. While the author has never omitted tubulating the pedicle, it is quite within reason to admit this and instead to protect the under surface of the pedicle with a cover of oiled silk. It is doubtful whether one has many advantages over the other.

Gillies[1] obtains a complete lid restoration by a method similar to the author's. He first buries a strip of cartilage under the skin near the outer canthus and allows it to take root there. The size of this cartilage is slightly smaller than the defect present. When the cartilage has received its new blood supply, the skin-cartilage-flap is raised and swung as on a hinge near the canthus. The skin forms the lining of the new lower lid, and the cartilage is on its anterior aspect. The lower borders of the skin flap are carefully sutured to the remains of the conjunctiva to complete the socket. There is now a raw area double the size of the flap, and it may be dealt with in one of the following ways: (*a*) The cheek wound may be closed by approximation and the lid portion Thiersch grafted; (*b*) a descending temporal skin flap may be swung down to cover both defects; (*c*) an ascending flap may be brought up from the cheek; (*d*) a double pedicle flap may be taken from the upper lid (Tripier); or (*e*), the skin may be conveyed to the lid by a tube pedicle from the neck. One very similar to this was devised by Kaz for the upper lid, and is included in the section dealing with upper lid reconstructions.

There is a second method for correcting the complete loss of the lower lid, wherein the so-called-hammock or bi-pedunculated flaps are taken from above the eyebrow and sutured in a position at the level of the inferior rim of the bony orbit. Later the extremities or pedicles of this hammock are returned to their original position. Still later the inferior edge of this transplanted piece of epithelium is raised and by dissection reflected upward and backward to form the posterior surface of the lower lid. The internal and external extremities are anchored in a normal canthal position, the lid margins sutured together either temporarily or arranged for intermarginal adhesions, and the anterior surface defect covered with a flap, an Ollier-Thiersch graft, or with a dermo-epidermic graft.

The third method available for the reconstruction of the lower lid was also described under reconstructions of the upper lid. A pedicle flap is

[1] Plastic Surgery of the Face, Oxford Med. Pub., September, 1920.

first used to relieve the epithelial or outer surface loss. The resulting entropion is then corrected ten days to two weeks later by means of an Ollier-Thiersch graft wrapped over a mold of dental compound and sutured in a dissection in the inferior cul-de-sac prepared there for it. As a result, a fornix of the proper depth is formed. The dissection for the preparation of this mold is considered under the heading of socket restorations.

Poulard recommends highly the use of thick pedicle flaps, which he eventually thins out, for the correction of deformities of the lids He presented a series of these cases in May, 1919, before the Thirty-second Congress, Société Française d'Ophthalmologie, Paris, showing remarkable results.

Figure 343 is a very satisfactory demonstration of the reconstruction of the floor of the bony orbit when the defect was so pronounced that the conjunctival cul-de-sac formed the only remaining roof to the maxillary antrum. The first illustration is the original defect, the second, immediately following the cartilage graft for the reconstruction of the entire floor of the orbit, the third shows such a thick pedicle flap from above the forehead for the correction of the soft tissue defects present, and the last, the final result after the pedicle was resected and the suture line thinned out

Budinger and Remky, and later Birch-Hirschfeld, first used ear cartilage. A concave-convex piece of cartilage, covered on one side with skin which projects 1 mm. beyond the cartilage, is taken from the ear and transplanted into the lid through an intermarginal incision, the skin side being faced toward the orbit. The outer surface is covered with a sliding pedicle flap. The piece of cartilage is fastened into the desired position with sutures, mattress sutures being used upon the free edge of the lid. Remky's modification is to take a trough of cartilage from the helix, which presents an open wound on the anterior convex surface while it is covered with skin upon its posterior concave surface. The cartilage is inserted into a freed marginal groove, the skin sutured to the conjunctiva and the free edge of the lid, the external defect being closed with mattress sutures. He claims that this method not only supports the lid, but on account of its broad surfaces lying in different places, any contraction of the connective tissue which later takes place cannot exert as much force and cause such pronounced changes in form as they would with a simple, flat piece of cartilage.

After the lower lid has been thus far completed, to the satisfaction of the patient as well as to the operator, it may be desirable to use a free skin graft at the margin of the lid for the reconstruction of the hair line. Normally, however, the lines of lashes in the lower lid are rather inconspicuous and their loss, not replaced, is not especially important.

Wendall Hughes recently presented a technique for rebuilding the lower lid following a carcinoma of the lower lid. The technique suggested by Axenfeld was most ingeniously utilized for a complete reconstruction of the lower lid. In his case, examination revealed a growth involving the major portion of the left lower lid, extending from the punctum to within 2 mm. of the lateral canthus, producing an entropion. It was not adherent to bone, but skin, tarsus, and conjunctiva were all involved. Surgical excision of the mass would mean removal of the entire lower lid. As Hughes said, in his original article, "This presented two major problems, to preserve the eyeball and to reconstruct a useful and normal appearing lower lid."

His technique, separately devised, as sent to the writer,[1] is as follows:

The entire lower lid was removed along the dotted lines in Figure 379 *a*, severing the skin and subcutaneous tissues well below the margin of the mass and the conjunctiva in the lower fornix. Laterally the incision was carried almost to the canthus and medially just beyond the punctum lacrimalis which was involved. This left a large defect for which a new lower lid was to be constructed. The skin of the cheek was undermined, sufficiently to allow it to be brought upwards to the level normally occupied by the lower lid without tension. The upper lid was split transversely into two layers starting along the intermarginal white line and dissecting upwards to a point even with the upper fornix about 3 mm. above the upper margin of the tarsus, not disturbing the attachment of the levator to its upper border. The inner layer was composed of the tarsus with its conjunctiva. The outer layer was the skin and subcutaneous tissue of the upper lid with the lashes attached. The lower epithelial border of the upper tarsus was cut off and this edge united to the cut conjunctival margin in the lower fornix by fine black silk sutures (No. 000 black silk) tying the sutures so the knots were on the conjunctival surface. The new position of the tarsus with the levator attached to its upper edge is shown in Figure 379, *b*. The previously undermined skin below was drawn upwards and attached to the anterior surface of the lower half of the tarsus by means of three double-

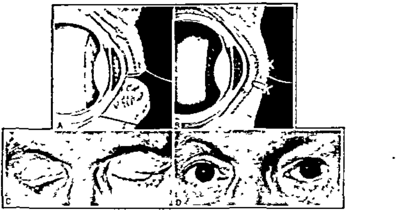


Fig. 379.—*A*, the dissection, *B* the sutures; *C*, end result with eyes closed, and *D*, with eyes open (Hughes, personal communication.)

armed black silk sutures, so the upper border was midway between the upper and lower borders of the tarsus. The superficial layer of the upper lid was then attached to the anterior surface of the upper half of the tarsus in the same manner so the lashes occupied a transverse straight line parallel and adjacent to the lower skin edge across the mid-portion of the tarsus. The two skin edges were aligned by a subcuticular stitch and the external portion of the lashes held upwards to the skin of the upper lid by collodion so the roots of the lashes would be in the proper direction. Rubber tissue was put over the area and a pressure dressing applied and left in place for six days. Subsequent dressings were at intervals of five days for three weeks. At the end of a month the second stage, transplantation of lashes, was done. A transverse trough was dissected down to the tarsus immediately below and parallel to the lashes of the upper lid. A strip of hairs to fit this trough was cut from the lower nasal portion of the opposite eyebrow and, reversing its position, end for end, was laid in it and sewn in position. The hairs were then held down by collodion to the skin of the lower lid to start them growing in the proper direction. Rubber tissue and a pressure dressing were applied and left in position one week. The dressing was changed again on the twelfth day and removed on the seventeenth day. The lashes in this strip did not fall out, but kept on growing. This was due to the ideal conditions created: the tarsal plate made an excellent smooth base and the additional raw tissues of the sides of the trough formed by the

[1] Personal communication.

dissection supplied ample mechanical and nutritional support for the graft. The proper direction of the lashes was accomplished by first turning the transplant so the portion that was nasal in the right eyebrow was placed nasally in the left lower lid and secondly by anchoring the hairs protruding from the graft to the skin forming the lower lid in the proper direction with collodion. The sutures, which were placed very close to the skin edges and tied tightly, were picked off at the first and second dressing one and two weeks later respectively. After another eight weeks, three months after the original operation, when it was seen that the lower lid lashes were growing in the proper direction and the lashes of the upper lid were complete (Fig. 379, *c* and *d*), an incision was made transversely between the two rows of lashes through the skin and tarsus to open the inter-palpebral fissure. The new lower lid was then complete except for a punctum and part of the lacrimal canaliculus which had to be removed because of involvement by the malignant process.

A procedure, slightly similar to this, is readily done in those cases where there is a gross conjunctival loss in the lower cul-de-sac and the eyeball has been lost. Figure 380 is such an instance. The technique is shown in the drawings of Figure 381. The hair lines remaining are first resected wholly from the two lids. As soon as these have healed, a flap is raised, hinged at

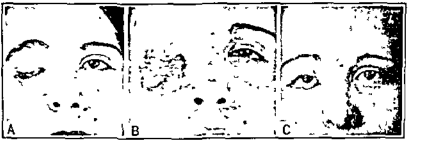


FIG. 380.—*A*, original defect, *B*, intermediate result, *C*, completed case

the lid margin, quadrilateral in shape, and this turned upward to be sutured upward into the lid margin of the upper lid—sparing the intact puncti if they are still present. The defect formed by the posterior surface of the flap and the site from which it was taken is then grafted flat with a razor-cut graft. See Figure 381, *D*. New hair lines are later implanted, and several months later a new palpebral fissure is incised beneath the hair line for the upper lid. See Figure 381, *C*.

Simultaneous Correction of Both the Upper and Lower Lids.—When this is necessary, it offers increased difficulties. If the method formerly explained, *in part, is used, the two surfaces exposed by respective reflections* upward and downward may be sutured together over a mold in the recess formed for the socket fornices and then simultaneously covered with one large flap from the neck. This flap may have a linear perforation for the palpebral fissure, or it can be lifted and divided at its apex into two distinct portions, the width of each depending upon the defect to be covered. If this is done the fine black silk sutures placed at the new lid margins may leave permanent intermarginal adhesions, or they may be so arranged that these will be only temporary. With the use of a pedicle flap, permanent intermarginal adhesions are not essential. The edges of the flap are sutured *as before stated into the anterior lip of those linear incisions,* forming the reflected portion of the new epithelial-conjunctival posterior surfaces of the reconstructed lids. Figure 380 illustrates this without further explanation.

The other alternative is to cover the lid defects formed with a large Ollier-Thiersch graft, as in the method suggested by Wheeler. When the above technique is used, a plastic restoration of the lines of lashes is possible according to that already described.

The defect formed by the simultaneous repair of both lids is too large for the use of a true skin graft.

When it is impossible to utilize the method just explained because a portion of the hair line remains, the lid margins may be incised and sutured together, *after the necessary dissection of the conjunctiva from the walls* of the bony orbit, through the external wounds in the lids. A flap is then raised from the neck, with its head or apex divided into two portions, patterned to fit the defects, and these sutured respectively in the operative defects in the upper and lower lids. The severe postoperative entropion resulting is, as before, later corrected as soon as the pedicle has been resected. This is accomplished through the use of an Ollier-Thiersch graft wrapped over a mold of dental compound.

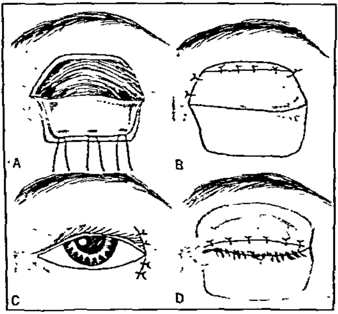


FIG. 381.—Hinged flap for lower lid (or both lids) blepharoplasty; *A*, the flap; *B*, its suture; *C*, incision of palpebral fissure, ocular prosthesis in place; *D*, grafted flap and hair line in place.

Figures 102 and 103 illustrate a technique for correcting the simultaneous loss of an upper and lower lid in the presence of an old enucleation. The first thing necessary *is the transplantation of a pedicle flap from the temporal* region so that one will have skin to form a lower lid shelf; in the original defect even this was absent. In moving this flap down, some of the hair follicles from the temporal scalp were inadvertently transplanted with it. These can be seen in the photograph. As soon as this had healed satisfactorily a hinged pedicle flap was raised from the outer angle. The anterior and posterior surfaces of the remnants of the lids were separated by marginal incisions and this hinged pedicle flap turned inward upon itself, and its epithelial surface sutured to the conjunctival surface of the lid

remnants. The apex of this correcting flap was purposely unattached. Before the sutures were tied a mold of dental stent was placed into the socket to fill out the fundus of the socket and to give support for counterpressure. A curtain was thus formed between the remnants of the upper and the lower lid but with a raw surface lying externally. This surface consisted of the posterior aspect of the flap as well as that position from which it was lifted. The latter of the two portions was closed rather readily by a quadrilateral flap. The pedicle of the flap which had been transplanted gave sufficient tissue for this. Triangle resection from the sides, to prevent kinking, assisted in the mobilization of the flap. The remaining raw surface was grafted flat with a razor-cut epidermal graft. Two months later a horizontal linear incision was made through the length of this lid for the formation of the palpebral fissure, and at the same time the irrigation hole at the inner canthus was closed by resecting its edges and suturing.

FIG. 382 —*A*, *B* and *C*, steps in the blepharoplasty for both lids palpebral fissure was completed as in Figure 380, except the epithelial lined flap was formed from beneath on the cheek. *D*, completed case

The patient is wearing a silver conformer in the reconstructed socket awaiting sufficient healing so that an ocular prosthesis may be ordered.

Figure 382 is a rather similar condition which was corrected somewhat differently. For this an epithelial-lined pocket was formed upon the cheek, this was then moved upward into the defect there. Before the correcting flap is raised in these cases, one must be certain of the nutrition of the flap. It is wise to first open the upper margin of the flap and to remove the retaining stent upon which the skin graft was wrapped; four days later to release the lower margin and to immediately resuture it into place; four days after this to detach the apex and resuture; four days later reopen the inferior margin and place a piece of oiled silk beneath it; and in another four days the flap should be so well supplied with blood-vessels that it is now safe to raise it to a correcting position across the opened palpebral fissure, the

edges are freshened, and the flap sutured accurately into position. The palpebral fissure can be made several weeks later. Figure 383 illustrates a similar situation, post-malignancy evisceration, with correction still incomplete. (See Fig. 382.) The lined pedicle flap has been raised to curtain the orbit for subsequent lids but is still not closed below; also there is a small unclosed area in the suture line at the upper edge of the flap. The next step here will be to close the lower edge of the flap, to incise the mid-line of the flap for the start of a palpebral fissure, and to close the opening above. From there on, the technique will be completed as described for the case in Figure 382.

A similar correction for both upper and lower lids in the presence of an intact eyeball could be corrected in an exactly similar manner, except that a pocket should be lined with mucous membrane rather than with epithelium. With this exception there is no difference in the surgery.

Fig. 383.—Lid correction, both upper and lower lids

Complete Symblepharon.—Complete symblepharon is a condition in which the epidermal surfaces of the lids are normal but the lids themselves are in blepharophimosis or each in a state of severe entropion through the loss of its inner conjunctival surface. The more or less complete loss of the orbital socket always accompanies the condition. The real state and meaning of a total symblepharon, that in which the mucous membrane of the lids is lost, is practically synonymous with the loss of the orbital socket. The reader is therefore referred to that section for this consideration. A socket, after an exenteration of all its contents, is perhaps the best example of such a defect.

Morax has offered a quite satisfactory method which may be utilized, following an orbital exenteration, with full satisfaction. In the presentation of this method he states, "I have come to the conclusion that it is far more convenient, in order to follow the grafting, openly to expose the parts to be grafted, and not to close the cavity until the graft is in good condition." It is drawing rather fine lines to separate the following technique from a classification for the reconstruction of the orbital socket, but the fact remains that this has for its basic purpose the correction of a lid deformity even though the surfaces of the lid at fault happen to form part of the limiting walls of the orbital socket. The operation as advanced can be conveniently divided into several steps for the purpose of description. The first step

consists of the release of the lid margins from their posterior and intermarginal adhesions by a straight horizontal incision. This incision thus follows the line of the normal palpebral fissure, though it should be 5 to 10 mm. longer. The incision ought to be 2 to 3 mm. in depth before any lateral dissection is done. Figure 384, *A*.

In the second step the lids are lifted from their entire attachments as two flaps, (See *B*). This is accomplished by a dissection carried on just underneath the surface of the epidermis of the lids. The dissection will thus elevate the two flaps, an upper and a lower, which are later to form the new lids. The sharp dissection carried on underneath the surface of the skin must pass as high as the rim of the roof of the orbit for the upper lid and to the same level, that is, the rim of the floor of the orbit, for the

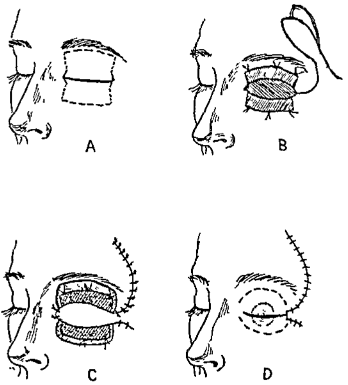


FIG. 384.—Autoplasty for complete symblepharon (Courtesy of P Blakiston's Son & Co)

lower lid. Morax states that it is well to lay bare these bony prominences The extremities of the first horizontal incision are then continued above and below at a right angle to the original direction of the incision for 2 to 3 cm. in a line that is now parallel to the long axis of the body, and the rectangular flaps thus outlined are raised. The one for the upper lid is adherent to the tissue just below the eyebrow, the flap for the lower lid adherent to the tissues of the cheek below the level of the rim of the bony orbit. At the place where the free edges of these two flaps touch the skin, for the upper lid below the eyebrow and for the lower lid on the cheek, when they are folded entirely outward and backward, a straight horizontal incision is made corresponding to the length of the free edge of the reflected flap. These flaps should be reflected without tension but still must lie

smoothly from the point of their attachment to these last-made horizontal incisions. As a third step, the free edges of the two flaps are sutured in the distal lip of the horizontal incisions with a dermol subcutaneous suture. When these sutures are inserted a large smooth rectangular, raw surface presents itself, to be covered by some type of graft. If the posterior wall or fundus of the socket has some conjunctiva remaining, this region will be subdivided into lesser, upper, and lower rectangles by this intervening bridge of mucous membrane from the fundus. If none is present, the entire fundus will enter into the correction obtained by the next step, that of placing a graft to cover the exposed raw surface.

There are several different ways in which this may be done. The first, and perhaps the simplest, is to cover the entire denuded area with a large Ollier-Thiersch graft from the arm or the thigh, placed into position without sutures, and covered with paraffinized gauze, tulle, oiled silk, or rubber tissue, and then dressed with a pressure bandage which should not be disturbed for eight days. Another method available is to cover the area with several large dermo-epidermic grafts from the arm. These will need only a few sutures and they are to be handled and dressed as if an Ollier-Thiersch graft had been used. A third method, and one somewhat better than the one just mentioned, is to cover the central portion of the denuded region with a pedicle flap from the outer temporal region of the face, and then place dermo-epidermic or epidermal grafts above and below the head of the pedicle. This divides the responsibility for reëstablishing the circulation and maintaining life in the adjacent grafts lying between this central pedicle flap and the horizontal skin attachments of the former free edges of the flaps. The circulation in the grafts will be more readily established when this method is utilized, and as a result failures will be less common. A large pedicle flap from the neck or chest can also be used.

The next step of the operation is carried out as soon as the graft which has been placed over the region representing the fundus of the socket and the posterior surfaces of the lids is entirely healed. This will be from two to three weeks. The attachments of the lid margins are then released and these areas carefully closed. The edges of the new lids are then sutured together in a complete tarsorrhaphy over a mold of dental compound corresponding roughly to the shape of the socket, though somewhat flattened from before backwards. The lateral inner canthal edges may be undisturbed, but it is well to place a small flat tape of gauze within the outer canthus to drain any secretions from the posterior surfaces of these new lids and from the socket.

The last step in the operation is then carried out from four to eight weeks after the intermarginal adhesions have been placed. These are released and the laterals carefully closed thus forming new and satisfactory canthal fornices. At the same time the mold can be discarded and a properly matched artificial prosthesis fitted. To quote Morax once more:

> These indications may inspire the operator in each particular case. It will be necessary at times to combine the dermo-epidermic graft method with the pedicled flap method to deal with a total symblepharon. For instance one can, after the incisions of the integument have been done, and the new lids reversed, cover the back of the new cavity with a pedicle flap taken from the temporal region, and only put dermo-epidermic grafts on the raw surfaces of the new lids. One can be assured, if the grafting evolves normally, that the back wall of the new cavity will

not undergo any reduction. It goes without saying that in these cases of total symblepharon and total restoration of the orbital cavity, the artificial eye is immobile, and that we cannot from the standpoint of cosmetic effect compare the result that we realize when an artificial eye is placed over a stump which has retained all of its mobility.

In the original article, in which this technique was presented,[1] there are two points mentioned by Dr. Morax which are copied here verbatim because of their importance. "Ces interventions n 'offrent aucune difficulté en elles-mêmes et leur succès est certain à deux conditions; la première, c'est que les paupiéres ou ce que reste de la surface conjunctivale ne soient plus le siegè d'aucune sécrétion anormale, d'aucune infection, la seconde, c'est que l'opérateur et ses aides appliquent a l'execution des interventions, comme du prélevement de la greffe, une asepsie rigoureuse."

[1] Annales d Oculistique March, 1918

The superior temporal vein is slightly behind the insertion of the superior oblique muscle. The inferior temporal vein emerges just behind the edge of the inferior oblique muscle and may be covered by the muscle. Anterior to the scleral exit each vortex has an intrascleral course of about 3 to 4 mm. At the inner side of the scleral canal lies the ampulla of the vein, somewhat wider (0.5 to 2 mm. in diam.) than the vein itself. (Fuchs, E.) while converging into these ampullæ from all directions, are a number of comparatively large tributary veins draining the entire uveal tract. Thus from about the equator to 8 mm. behind the equator are areas above and below which preferably should be avoided in surgical approaches through the sclera.

Figures 385 and 386 show, in a diagrammatic manner, the external projection of the anterior and posterior segments of the eyeball.

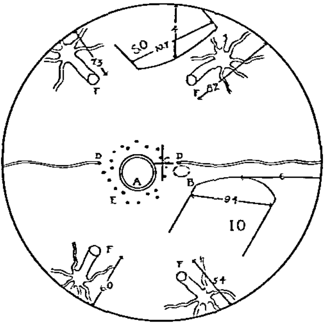


FIG 386.—Projection of the posterior half of the globe measured on the sclera; *A*, optic nerve, *B*, macula *C*, posterior pole, *D*, long posterior ciliary arteries; *E*, short posterior ciliary arteries, *F*, vortex vein with ampulla and tributaries (see Plate IV) (Cowan)

THE CORNEA

The cornea is a segment of a transparent hollow sphere inserted into the anterior scleral foramen. The radii of curvatures of the anterior and posterior surfaces are 7.7 mm. and 6.8 mm. respectively (Gullstrand). The thickness in the axial portion is about 0.5 mm.[1] Continuing the curves as given, the thickness at the corneo-scleral junction is about 0.6 mm. (Scammon and Armstrong). The anterior surface of the cornea is an oval with its long axis horizontal, measuring 10.6 mm. by 11.6 mm.[2] The posterior surface is a circle with a diameter of 11.6 mm. This overlapping of the cornea by the sclera in the vertical meridian may be still more marked in some cases.

[1] Blix, Uppsala Läk Förh., 15, 349, 1880

[2] Smith, Priestly, Trans. Ophth. Soc United Kingdom, p 68, 1890, On the Size of the Cornea, etc.

DESCEMET'S MEMBRANE

It should be emphasized that Descemet's membrane may be readily detached (as Cowan said) not only by fluids, infiltrates, and tumors, but also by contact of instruments. Fuchs[1] stated that detachment of Descemet's membrane resulting from surgical procedure is extremely frequent, as observed with the slit lamp by Sallman;[2] by Samuels;[3] and by Arkhsangelskaya.[4] Usually it occurs when the iris is replaced with a spatula during iridectomy for glaucoma. The operator fears lest he inadvertently come in contact with the lens and injure it, and so he direct the spatula more toward the cornea. In this way the spatula is introduced between Descemet's membrane and the corneal stroma. At first the operator meets with resistance, and only after he has unconsciously lacerated Descemet's membrane is he able to move the spatula more freely. There is histological evidence to show that there is some regeneration of a destroyed portion of Descemet's membrane. This occurs much later, however, than the regeneration of the endothelium.

THE IRIS AND THE ANTERIOR CHAMBER

Normally, the root lies 1.6 to 1.8 mm. straight back from the corneoscleral margin while the plane of the anterior surface of the lens (Salzmann) on which the pupil rests, is at least 0.6 mm. in front of this. The exact shape of the iris cone varies considerably in different normals, while certain pathological conditions cause gross abnormalities. The normal thickness of the iris is 0.4 to 0.6 mm. (Salzmann), but here also there is considerable variation; the iris becoming thinner during contraction of the pupil and thicker when it is dilated.

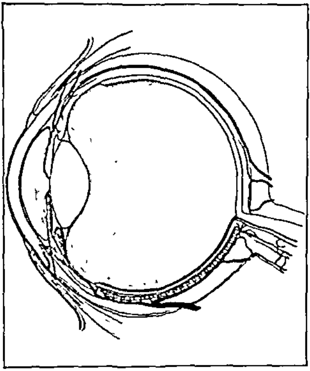
The blood-vessels of the iris, derived from the anterior and posterior ciliary arteries, enter at the iris root, and are arranged in characteristic fashion in the stroma The narrow anterior border layer, just under the endothelium, is somewhat denser than the rest of the stroma and is avascular. In certain diseased conditions, occurring in glaucoma, diabetes, and in iris atrophy, it is often extremely friable and bleeds readily. In these conditions also, the pigment is loosely held in the cells and may be dislodged during manipulations, into the anterior chamber, where it is apt to clog the angle meshwork.

The iris is extremely liable, especially when inflamed, to form adhesions to any structures with which it comes in contact. However, when cut, especially tangentially, it retracts and no healing or closing over of the whole takes place. So also, iris tissue interposed between wound edges prevents their firm healing. This seems due to the pigment-bearing cells. It may be mentioned that the iris root is the thinnest part of the membrane and also contains the largest vessels. When subject to trauma the iris parts here, and the wound bleeds more than with wounds placed otherwise.

The topography of the anterior chamber as a whole is shown in Figure 387. It will be seen that it is slightly wider than the corneal diameter. The normal depth of the anterior chamber varies considerably. It is usually

[1] Arch Ophth., vol 16, September, 1936.
[2] Verhandl d Wien ophth. Gesellsch., p. 66, 1924–1925
[3] Trans Am. Ophth. Soc., 26, 427, 1928.
[4] Sovet, vestnik oftal, 5, 516, 1934; abstr, Zentralbl f. d. ges. Ophth, 33, 451, 1935.

PLATE II



The essentials in the circulation of the globe, excluding the central retinal artery and vein. The long and short ciliary vessels and the vortex veins are the elements. (See Plate IV.)

deeper in myopes, shallower in hyperopes. It is also shallower in eyes with small corneas and in the aged; this is due to the increased thickness of the lens and the flattening of the cornea. As the refractive power of the cornea is approximately 32 diopters (*the refractive index of the aqueous being 1.3*) objects in the anterior chamber such as the iris, pupil, lens or cataract knife will appear one-third nearer the cornea than they really are, and will be magnified according to their distance from the corneal surface. For this reason in performing the counter-puncture of a corneal incision, the knife point emerges from the eye about one-third further back from its apparent position in the anterior chamber.

The chamber angle is a narrow cleft even in the normal, and dilatation of the pupil as well as many pathological conditions render it still narrower. With the various planes and entrance points for incisions in relation to the angle and other structures of the anterior chamber it will be noted that the more tangential the incision the wider apart are the lips of the wound, and the shorter the length of the incision in the posterior corneal surface, as compared with that in the anterior.

THE LENS

The substance of the lens is made up of lens fibers which are much elongated cells of epithelial origin. Although the slit lamp reveals a complicated nuclear arrangement at all periods, the lens substance in earlier life has approximately the same structure and consistency throughout. It is very soft, sticky and malleable. When exposed to aqueous humour as through capsular wounds, the fibers swell, become white and fluffy, disintegrate, and are completely and fairly rapidly absorbed. As new lens fibers are continually being formed at the equator, the lens increases through life in both diameter and thickness and the equatorial edge becomes thicker and more rounded. The density increases in later years, even more markedly, for the old fibers are squeezed toward the center where they finally become a closely packed amorphous and sclerotic mass. The surgical nucleus, (that portion of the lens which, as in a cataract operation, is mechanically and pathologically separate from the cortex) on coming in contact with aqueous, swells little and is absorbed slowly and incompletely. The surgical nucleus appears at about the thirtieth year,[1] and increases in size and hardness with age, but shows marked individual variation. It becomes quite large, after fifty years approaching the anatomic adult nucleus in size. Occasionally the whole lens takes on the nuclear characteristics.

The capsule of the lens, although it forms a continuous envelope around the lens substance, has been divided into the anterior capsule covering, the anterior curvature of the lens, and the posterior capsule covering the posterior curvature. The thickness of the capsule, as given by Salzmann, varies in different portions. It will be noted that the thickest portions of the capsule both anteriorly and posteriorly are proximal to the lens equator. *Here on the anterior capsule is afforded the safest forceps grip for intracapsular extraction.* It is at the outer edge of these thickened portions that the zonular fibers are inserted. The capsulo-hyaloid ligament is attached to the thickening of the posterior capsule. The posterior capsule

[1] Parsons, Diseases of the Eye, 6th ed., Macmillan Company, p 296, 1931.

is thinner than the anterior capsule, as a whole, and both portions of the capsule are thinnest in the axial region. When the thin axial portion of the anterior capsule and the lens substance are removed in extra-capsular extraction, the posterior capsule and the thick portion of the anterior capsule to which the zonule is attached, remain in the eye as a diaphragm extending in front of the hyaloid membrane. Histologically the capsule is a structureless, glassy membrane resistant to the solvent action of the aqueous. It seems to be under some tension, and the edges retract and curl out when incised. It seems elastic and can be grasped in a fold with forceps In some conditions, as hypermature cataract, the capsule is brittle or weak. It is stretched tautly in intumescent cataract so that it can be grasped only with difficulty.

The diameter of the entire lens in mm., at different ages, is as follows (Priestly Smith):

Age	20-30	30-40	40-50	50-60	60-70	70-90
Diameter	8 67	8 96	9 09	9 44	9 49	9 6+

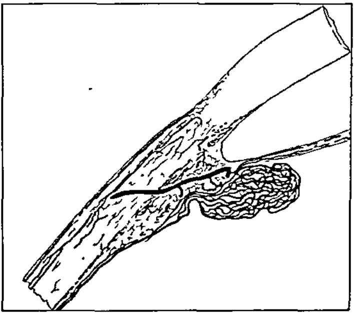
The zonule consists of fibers arranged in two main sheets or groups. Those of the anterior sheet originate from the ciliary body and from the base of vitreous just in front of the ora serrata. They run forward and inward in the valleys between the ciliary processes and are attached to the lens capsule slightly axial to the equator. The weaker posterior zonular sheet is composed of more delicate fibers coming from the anterior and inner surface of the ciliary processes, all of which pass backward and inward to be attached to the posterior capsule slightly axial to the equator of the lens. In addition to these main masses to the zonule, a few fibers from both sheets pass into the equator of the lens.

In youth and early adulthood, the zonule has considerable tensile strength, but after forty years of age, it becomes progressively weaker and more brittle. Weakness of the zonule is also present in such pathological conditions as high myopia and uveitis.

The lens is thus held in place by several agencies. The iris and pupil exert some pressure in front. The two sheets of the zonule attach it to the ciliary body. In back it is held by the capsulo-hyaloid ligament and by the capillary attraction between the posterior capsule and the hyaloid membrane in the patellar fossa.

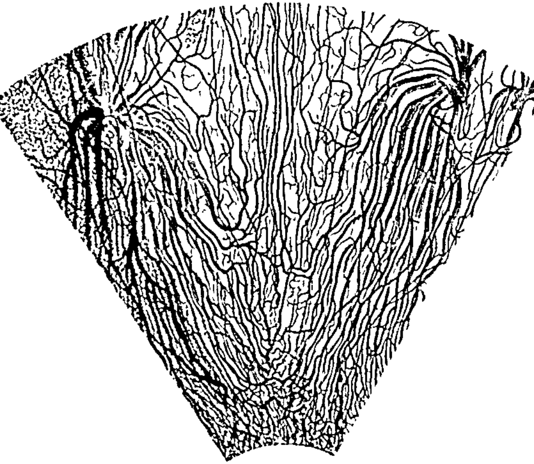
Marked changes in the relations of the intra-ocular structures occur when an opening is made into the anterior chamber. The intra-ocular pressure forces all fluid in the eye toward the opening, where the pressure is zero. Movable structures impeding this flow are carried with the fluid. The hyaloid, lens, zonule, ciliary processes and iris all move forward, and the anterior chamber becomes shallow or obliterated. The iris, especially when the pupil is small and the opening large and peripheral, is very liable to be carried into the wound by the flow of aqueous from the posterior chamber. If the cornea is thin and inelastic, it may be dented in by the atmospheric pressure, and if it later resumes its normal shape, blood or air may be sucked into the eye. (Fuchs, E.) Furthermore, as the delicate intra-ocular arteries are no longer supported by the intra-ocular pressure, they dilate, and the uveal tract becomes engorged and swollen. This may cause great pain. If the vessels are diseased they may rupture. A secondary rise of tension

PLATE III



Circulation of the anterior chamber, the root of the iris, and the ciliary body, illustrating the position of Schlemm's canal, and showing the anatomical relationships connected with surgery at the limbus. (Modified *after Leber.*)

PLATE IV



Schematic topographic view of the formation of the vortex veins, and the points of entrance, near the papilla, of the long and short posterior ciliary arteries. (Modified after Leber.)

llows the engorgement if the wound is quickly sealed, (Abraham[1]) and his may suffice to reopen the wound.

THE VASCULAR SYSTEM OF THE GLOBE

The blood supply of the globe is the short and long posterior ciliary ries and the anterior ciliary bodies, the venous drainage being by means he vortex veins, and the posterior and anterior ciliary veins. Both ries and veins give fine branches to the sclera, their principal function, ever, being circulatory to the choroid. Plate II shows schematically correctly, from an anatomic standpoint, the arterial and venous supply pting only the central artery of the retina, which is a terminal branch of internal carotid. According to Leber, one can divide the arterial supply a posterior and an anterior system. The anterior is rather closely nected with the arterial supply of the ciliary body and of the iris, while posterior portion is largely connected with the short ciliary arteries. re are rather close anastomoses between these two systems, however, ished by posteriorly directed branches from the anterior system and the nections from the long posterior ciliaries with the anterior ciliary arter- In this way, the anterior portion which is basically supplied by the posterior ciliaries is intimately anastomosed with the supply entering eye by means of the short posterior ciliaries. The chorio-capillaris r is largely the terminations of the short posterior ciliaries. The ter- ations of the long posterior ciliaries are in part to the choroid, to the ry body, and to the iris. In the iris itself, there are two separate net- ks of capillaries, a larger superficial network, and a smaller and much r network of capillaries about the sphincter pupili. At this place the stomoses between the long posterior ciliary and the anterior ciliary is as nsive as are the former anastomoses just discussed. Both enter into formation of the iris plexus especially (Plate III).

The venous supply cannot be divided as definitely as can the arterial ply. The major portion of the venous blood leaves the eye by the means the vortex veins. These are formed by collecting branches from the rio-capillaris from the ciliary body and from the iris. In addition there n extensive venous plexus from the ciliary body about Schlemm's canal still more externally are the anterior ciliary veins, all terminating as erior radicles of a vortex (vorticose) vein. The very small posterior ary veins drain sclera alone and do not receive any venous blood from choroid.

The blood supply of the retina depends upon the central artery of the na and the central vein of the retina. There are vague and indeterminal stomoses occurring between branches from the central artery of the ina, leaving at the papilla with terminal branches of the [illegible] eries. In addition there is a fine capillary plexus in the optic nerve itself imately connected with the arterial and venous supply of the choroid. te IV shows the formation of these vortex veins, and illustrates [illegible] ambiguity the reason and necessity for evading them is [illegible] for instance, that connected with retinal separation.

[1] Anterior Chamber Puncture in Relation to Intra-ocular Tension, [illegible]
2.

CHAPTER XV

SURGICAL CONDITIONS OF THE CONJUNCTIVA.

These are, in general, neoplastic, congenital defects, cicatricial conditions resulting from traumata, and surgical conditions arising from chronic irritative inflammatory diseases. The subdivisions of these will include the following:

Neoplasms	Hemangioma, malignant papilloma; epithelioma; sarcoma; melanoma.
Congenital defects	Epitarsus and the presence of a third eyelid; nævi (see above hemangioma), congenital dermoids; lipomata; colobomata.
Cicatricial conditions	Ectropion, entropion, trichiasis; symblepharon; lagophthalmos; ankyloblepharon.
The results of chronic irritative conditions	*Foreign bodies* in conjunctiva; pterygium; conjunctival cysts; benign papillomata.
The results of *chronic inflammatory* diseases	Trachoma; ectropion; *entropion*; ptosis; trichiasis; and symblepharon po-*terioris*; vernal catarrh; pemphigus or essential shrinkage of the conjunctiva, conjunctival concretions; polypi; tuberculosis of the conjunctiva.
Conjunctival plastics	Conjunctival flaps for acute and recent corneal pathological changes; ulcers, keratitis paralytica; perforating wounds; complications following *late after intra-ocular surgery.*

NEOPLASMS OF THE CONJUNCTIVA

These may be benign or malignant. The major number of benign tumors of the conjunctiva are the result of chronic irritative conditions. Others are congenital defects as nævi and congenital dermoid cysts. The neoplasms are the hemangiomata, epitheliomata, and sarcomata.

Hemangiomata are rare and usually involve the caruncle and are frequently continuous with and contiguous to a hemangioma of the skin of the lid. Tiny hemangiomata are not uncommon and can be removed wholly with a fine cautery needle, under local anesthesia. The larger hemangiomata *rarely become malignant, though not uncommonly they increase in* size. Hæmorrhage may occur within them, and calcium deposits appear. Cautery removal is to be used if this is possible. Roentgen-ray therapy is especially valuable. Hemangiomata are rather likely present at birth and as such are either capillary or cavernous in character.

Malignant Papillomata.—The hard papillomata of the skin contain dense fibrous tissue forming the papilla, and contain few blood-vessels. The papillomata of the conjunctiva are soft, the fibrous tissue is sparse, and they contain many thin-walled blood-vessels. Many of these are premalignant papillomata. Wolff[1] speaks of them as sessile nonpigmented tumors, slightly nodular and pinkish in color. He states further, "the tumor tends to grow over the cornea, involving for a long time the superficial layers of the cornea and the sclera, and only later does it invade the eyeball. It later becomes malignant and may give rise to secondary deposits in the connected lymph glands."

In the treatment of these tumors which is always *surgical*, the question of biopsy constantly arises. For biopsy of these small tumors of the con-

[1] A Pathology of the Eye, London, H. K. Lewis & Co., p. 39, 1935.

junctiva without sharp dissection, *i. e.*, by cautery knife, see below. Slit lamp examination frequently is of great assistance. Malignancy in the conjunctiva has a characteristic vascular supply which is separate from that of the contiguous conjunctiva. The blood-vessels in the surrounding conjunctiva run up to the tumor mass but they do not always penetrate it, instead, the greater portion of the return loops are directed away from the mass. The separate blood-vessels in the tumor mass are not connected with the other visible conjunctival vessels. Inflammatory lesions and non-malignant lesions do not show this double and separate vascular supply. This may be of assistance in the diagnosis of a non-pigmented papillomata. In many instances it may seem wise to remove the tumor mass in its entirety for microscopic examination. The fine cautery tip of the Ziegler cautery outfit can be used as a scalpel. The tumor mass may be grasped *at its central portion, traction applied and removed by light, accurate* strokes with the cautery. No more damage should be done to the underlying tissues than one would do by sharp dissection. If the entire cornea is covered, or examination shows invasion of the cornea or the sclera, one cannot adopt this procedure for malignant changes have already developed.

Epitheliomata.—*Epitheliomata of the conjunctiva appear usually at* the limbus and ulcerate rather early in their course. In addition they are, early in their course, almost transparent, and the surrounding conjunctiva is much more congested, and the contiguous cornea may show infiltration and clouding. A true epithelioma tends to grow very slowly for a short *time; then, if not diagnosed and treated, it infiltrates the cornea and the* sclera, penetrates into Tenon's space and spreads rather rapidly. Invasion of the eyeball occurs through the vortex veins canals.

Sarcomata.—Sarcomata are rather rare and in the cases seen by the author have always occurred in the later years of life. Wolff and Collins *state that they may develop from nævi. A sarcoma is usually pigmented* and is more or less mushroom in shape, over-growing the cornea, conjunctiva and the sclera, but maintaining a small base with but little infiltration of the neighboring underlying tissue.

Inflammatory Granulomata.—From a differential standpoint the malig*nant neoplasms may be confused with inflammatory granulomata, with* tuberculous lesions of the conjunctiva and with gummata. If possible a diagnosis should be made, as implied before, without biopsy. If biopsy is necessary cautery removal is perhaps the safest, and one should be prepared for either complete and subsequent removal of the lesion or even for an *enucleation. Satisfactory results can be obtained, following biopsy exam*ination of a frozen section with the immediate cautery removal of the tissue, and subsequent radium therapy. In such instances the conjunctiva should not be sutured.

In malignant lesions, especially when small, there is no doubt that the *finest results follow adequate treatment by radium. For a further consider*ation of malignancy and for the technique of radium therapy as applied in ophthalmology see Chapter XXVI.

Inflammatory granulomata will have a preëxisting cause, the vascular supply of the polyp is rich and continuous with the corneal vessels, and *more or less chronic suppuration is often present.* Tuberculosis seems to be distantly connected in many cases. Gummata are always confusing. The presence of a positive Wassermann does not preclude the possibility of a

sarcoma or an epithelium. Gummata, however, are much less common, even than malignant neoplasms of the conjunctiva. They have apparently no age relationship, they do not ulcerate, are not pigmented, may not be at the exact limbus and their vascular system and supply also is not integral to the mass. Further they show no tendency to invade the surrounding conjunctiva. They do cause as great or an even greater reaction in the adjacent cornea than do epitheliomata. The degree of pain present is perhaps somewhat greater in epitheliomata.

CONGENITAL DEFECTS OF THE CONJUNCTIVA

Epitarsus and the presence of a third eyelid are quite rare. It is a cosmetic blemish which needs careful removal and suture. These cases are rather similar to epicanthus in that they tend to decrease past the age of infancy into that of childhood. Under ordinary circumstances, therefore, it is quite wise to delay the surgery as long as is consistent with the case and with the age and the health of the child. In general, they are to be operated after the fifth year of life, and an even longer delay is permissible.

Nævi have been considered, in part, with hemangiomata above, in that they are congenital cavernous hemangiomata. They may become sarcomatous, and should be removed with a micro-cautery needle, or with unipolar diathermy desiccation. Roentgen-ray therapy is also applicable to these. Congenital dermoids are also rather rare, are often times bilateral and more or less symmetrical. (Fig. 245.) Their commonest position seems to be in the upper outer angle of the eyelid. They are also most common in the upper outer angle of the orbit when retrobulbar. The case illustrated, however, showed tumor masses in the inferior cul-de-sac in each eye, two masses in the superior cul-de-sac and the bulbar conjunctiva of the right eye, and one large mass up and out in the conjunctiva of the superior cul-de-sac of the left eye. These must be removed in their entirety and the conjunctiva closed, either by pedicle flaps if sufficient conjunctiva is still available or the operative defect must be corrected with mucous membrane grafts. The microscopic examination of these dermoids will show extensive xanthomatous infiltration in much of the neighboring conjunctiva. In the surgery of these cases, therefore, one must remove all of the thickened and leather-like pathological tissue. Huge nævi may demand extensive skin grafting.

Lipomata are soft nodular tumors usually appearing in the external angle under the conjunctiva of the cul-de-sac of the upper lid. They can be removed without difficulty by clean sharp dissection and the conjunctiva closed with a few sutures. Coloboma of the conjunctiva are accompanied by colobomata of the skin as well, and they may extend, in degree, from a small indentation of the free border of the lid to a very large quadrate or triangular gap. The surgical correction of these has been considered.

CICATRICIAL CONDITIONS OF THE CONJUNCTIVA

Ectropion, entropion, trichiasis, lagophthalmos, and ankyloblepharon are cicatricial conditions of the conjunctiva and have already been discussed in sufficient detail. Symblepharon can be divided, arbitrarily, into anterior and posterior types. This subdivision means that in the former a

bridge of healthy conjunctiva which passes beneath the adherent band from lid to bulbar conjunctiva is absent in the posterior variety; that is, the symblepharon is adherent throughout its length from the conjunctival surface of the lid to the conjunctival surface of the globe. These conditions may be of varying degrees. The symblepharon may be merely a deep cul-de-sac adhesion as seen commonly after minor caustic burns of the conjunctiva in the lower cul-de-sac, or it may be so extensive that the entire conjunctival surface, palpebral, bulbar, and corneal, is lost. Clinically, if *the entire corneal epithelium has been destroyed, a mucous membrane graft* will enable one to preserve the eyeball, but the visual acuity present will be only light and colored light perception. Further, it is rather likely that keratoplasty will never be successful, neither homo-grafts nor iso-grafts, for corneal transplants in the absence of healthy conjunctiva.

Occasionally the lower lid defect as seen in trachoma and in essential shrinkage of the conjunctiva, often spoken of as ocular pemphigus, becomes so pronounced that the inferior cul-de-sac is wholly lost and the conjunctiva with its buried cicatricial bands, passes directly over from the everted lid margin to the limbus, limiting the movement of the eyeball, causing the patient considerable distress, and, by reason of the irritation due to the exposure, aggravating the condition by the establishment of a vicious circle. The extensiveness of these forms of symblepharon does not complicate the surgery, however. In the trachomatous cases, the inferior tarsal plate first *must be resected with the overlying adherent cicatrized conjunctiva,* and five to eight days later a mucous membrane graft used for the reconstruction of the cul-de-sac because of the symblepharon. Cicatricial symble-*pharon which occurs in the inner angle is the most difficult of all to correct.* Most of these cases also have extensive scarring of the cornea. In them as in any type of symblepharon an attempt should be made to preserve the eyeball whenever clear cornea can be seen, even though it be only at the limbus. An optical iridectomy following the reconstruction surgery for the symblepharon, will give most usable vision.

There are, in general, three forms of surgery available for the correction of a symblepharon. The first is the Arlt technique; the second, the Teale and Knapp techniques utilize conjunctival pedicle flaps; the third is connected with the use of a mucous membrane graft.

In the Arlt technique, especially applicable to anterior symblepharon, a double-armed suture is carried through the head of the symblepharon band at its conjunctival attachment, the sutures are passed through the depths of the cul-de-sac and out upon the skin of the lower lid. The adhesion is then cut from the cornea and drawn down to the depths of the cul-de-sac by a mattress suture which is tied over a small gauze roll or through a pearl button. The edges, in the defect of the bulbar conjunctiva, are sutured in a vertical line. Blaskovics advises using a double-armed mattress suture for the lower suture on the bulbar conjunctiva. This is brought out upon the lid surface and tied below the mattress suture first introduced. Figure 388 *illustrates this technique in a diagrammatic manner.* The *same surgery* can be used for the correction of a small posterior symblepharon. In such instances, however, it is well to put a mattress suture in the lid margin of the lower lid as a traction suture. *This will evert the palpebral conjunctiva* and allow it to be closed in the same vertical line continuous with that on the bulbar conjunctiva. In these instances the Blaskovics double-armed

suture can be used. Czermak called attention to the fact that in some of these cases it is well to do a wedge-shaped tarsectomy, removing the adherent symblepharon, and then uniting the cut surfaces of the tarsus, the palpebral and the bulbar conjunctiva, with a line of vertical sutures sim-

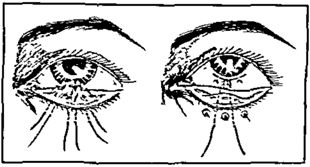


FIG 388.—Arlt's technique for symblepharon. (After Török and Grout)

ilarly. When utilizing this technique, an intermarginal tarsorrhaphy must be made the width of the symblepharon, and the tarsus resection outlined from that by two converging incisions including the symblepharon and the tarsus for resection.

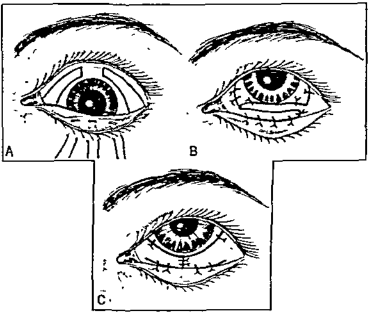


FIG. 389.—*A*, symblepharon correction by transplant; *B*, symblepharon Teale-Knapp flaps; *C* is the Knapp correction.

Posterior symblepharon and all other symblepharon of any great degree must have one or more conjunctival pedicle flaps for their correction. This applies especially to the broad-based forms of symblepharon commonly seen after caustic burns. One or more, as is necessary, double-armed mattress sutures are first placed in the head of the symblepharon as outlined in Figure 389, *A*. The head of the symblepharon is then resected, and the

symblepharon is drawn down into the depths of the cul-de-sac with the sutures as illustrated in Figure 389 *A*. These are tied there through pearl buttons. One or two conjunctival flaps are then outlined from the conjunctiva lateral and/or, medial to the limbus, the wider of the two arising from the conjunctiva lateral to the limbus because more is available there (see section on surgical anatomy of the conjunctiva), while the lesser of the two is taken from the medial surface. The flaps are then brought down one above the other as in *B* of Figure 389. Before the flaps are cut free, the conjunctiva should be widely undermined even to the superior fornix, and well into each canthal angle. Without this one cannot gauge the amount of the conjunctiva which is available for the surgery, nor can one be certain of the ability to close the conjunctival defect at the place where these flaps are being lifted. In general, it is usually best to place the wider of the two flaps above and the narrower of the two below. The flaps must be sutured one to the other, and the lower margin of the lower of the two is to be sutured into the depths of the cul-de-sac, to the edge of the conjunctiva there, which had been drawn down by the mattress suture. Because of this it may be wise, in most of these cases, to tie the mattress suture first in a bow knot so that it can be subsequently released to facilitate the introduction of these sutures, then secondarily, tied in a square knot and the ends cut short. Both eyes are to be dressed for the first four days. After that the unoperated eye should be left open, and the patient advised to move this unoperated eye about freely. It will cause some pain at first, but it will minimize formation of subsequent cicatricial bands in the operated eye. The sutures should not be removed before the eighth day unless they open spontaneously. In many of these instances the upper edge of the greater of the two flaps will not cover all of the corneal epithelial defect. This is of no great concern, in that the intact epithelial of the cornea will migrate there above the cicatrix.

In cases of posterior symblepharon wherein the width of the symblepharon is not as great, Knapp's two quadrangular horizontal flaps can be formed from contiguous conjunctiva on the two sides of the vertical bulbar defect and sutured together in the mid-line, as shown in Figure 389, *C*. In some of the conjunctival plastics for symblepharon it may be wise to dress the case for the first three or four days with a glass conformer to maintain the depths of the cul-de-sac, as reformed, and to hold the conjunctival flaps in accurate coaptation against the sclera.

Symblepharon of more extensive degree, and all forms of symblepharon at the inner and outer angles and of the superior cul-de-sac must be corrected with mucous membrane grafts. The Chapter on Diseases of the Lids illustrates such a case and shows the degree of movement possible thereafter. The symblepharon must first be cleanly resected from the bulbar as well as the palpebral conjunctiva. The conjunctiva should be incised close to the lid margin, then undermined and carefully pushed upward onto the globe and to the sides, so that there will be no limitation in the movements of the eyeball following the completion of the surgery. The lower edge of this may be sutured to the episcleral tissues if necessary, with very fine black silk. A pattern of the defect on the bulbar and on the lid is then cut from oiled silk, and a mucous membrane graft removed from the buccal mucosa. This is placed in warm salt solution while the mucous membrane defect in the mouth is closed. The mucous membrane graft is

then pegged out upon a tongue blade or placed, epithelial surface downward, upon a towel on the ball of the thumb and carefully trimmed until maximum thinness has been obtained. While this is being done, the graft should be moistened from time to time with warm saline solution. As soon as the graft is suitable, it should be carefully stretched, the epithelial surface innermost, across the palpebral fissure in the correcting position, *i. e.*, if it is a symblepharon lateral to the limbus, it would be stretched across the external commissure; if medial to the limbus, across the internal commissure; and if for the inferior or superior cul-de-sac, across the palpebral fissure. The lids are then separated with the finger tips and a glass or silver conformer (previously selected as proper in size and fit) is carried into the conjunctival cul-de-sacs, infolding the graft upon itself into the correcting position. The lids are allowed to close and the conformer lightly massaged through the closed lid to smooth out any possible folds in the graft. The lids are then opened and further adjustment of the graft, if this is necessary completed with fine conjunctival forceps. The case is then dressed with a pressure bandage, both eyes being covered, and this not changed until the fourth day. One must be careful in the selection of the conformer that the cornea fits into the perforation of the conformer so that no damage will occur to it. If the conjunctiva is denuded in the resection of the symblepharon, the graft should cover this. It will be a simple matter to trim the graft subsequently if it is too large. A pseudo-pterygium-like cicatrix will develop in some cases where the denuded cornea is not covered with the mucous membrane graft. In the dissection necessary for the preparation for these grafts, the operator must be careful that all cicatrix is removed and that the eye can be readily moved in all of the cardinal directions. Even necessary muscle surgery should be done at this time, buried catgut sutures being used, however, and not silk. This all may be completed in a one stage operation but it should be done before the graft has been cut.

CHRONIC IRRITATIVE CONDITIONS OF THE CONJUNCTIVA

Foreign Bodies in the Conjunctiva.—The removal of foreign bodies in the conjunctiva is a simple matter. It is not uncommon for cilia, slivers of wood, thorns, and the hard chitinous scales of grain to become embedded in the conjunctiva. Very careful examination is often necessary to discover these. The history of the case is usually sufficient to decide that some such condition must be present. Cases are seen, however, wherein all of these above-mentioned foreign bodies were present, up to seven days, before being diagnosed and removed.

Pterygium.—Etiologically, pterygium is probably the result of chronic irritation. It is rather common knowledge to all ophthalmologists that in the warmer climates pterygium becomes more frequent, and in the tropics assume proportions which are almost malignant in character. Elliot early called attention to this in his Tropical Ophthalmology. Occasionally severe recurrent and unusual pterygium cases present themselves where a great conjunctival loss is present. One such case had three operations, the first a simple resection, the second a McReynolds, and the third some modification of the Desmarres. In this, as must be in others, the eyeball was limited in both external and internal rotation, and diplopia was present. The cases assume, for all practical purposes, the degree of a posterior symblepharon.

Various operations are available, depending upon the extent of the new growth: as resection, conjunctival transplants, rotated conjunctival island flaps, and resection combined with the use of mucous membrane.

Ziegler's dictum as to the indications for pterygium surgery and the essentials of a pterygium operation are all-embracing. He states,[1] "It should be removed (1) when it is progressive; (2) when it interferes with vision; (3) when it limits ocular motility; (4) when a capital operation on the globe is planned; and (5) when it is cosmetically disfiguring." His requisites for success in the operative treatment of pterygium and the essentials for a satisfactory operation are to allow for a thorough removal of the head of the pterygium, leaving clear corneal tissue; there should be excision of the conjunctival tissue, especially about the limbus; it should permit complete closure of the conjunctival wound with close approximation to the limbus; one must avoid tearing of the conjunctiva and prevent tension upon the sutures; and the surgery should allow for rapid primary union with as thin a conjunctival flap as it is possible for it to obtain.

Resection or Excision of a Pterygium.—Electrocoagulation of a pterygium has been recommended by several people.[2] The writer has used it satisfactorily in a few instances as an office procedure when hospitalization of the patient could not be carried out and the pterygium was small. It demands from two to six treatments. These are painless with instillation anesthesia, and the patient is not greatly incapacitated. The finest wire electrode cautery possible should be used and the electrocoagulation or actual cautery treatment started at the apex of the pterygium. If electrocoagulation is being used with a diathermy current, its intensity should be cut down to a minimum spark to prevent damage to the underlying cornea and sclera.

There are two very satisfactory operations for resection or excision. If resection or the excision method is properly carried out in many of the small pterygia seen, the results should be uniformly satisfactory. Campodonico[3] also spoke of the great frequency of pterygium in the tropics as compared to the temperate zones. In the tropics pterygium operations are a daily occurrence. The type of resection which he uses has given him full satisfaction over a period of twenty years. With Campodonico's technique the operation is performed in three steps: (1) dissection of the pterygium's head out of the cornea and adjacent sclera by means of the angular keratome; *(2) excision of the pterygium's head and body by means of small* scissors; and (3) suturing of the flaps. The anesthetic should be by instillation and not by subconjunctival injection, as the areolar infiltration resulting from the injection is detrimental to the accurate subsequent coaptation of the flaps. The first two steps are not unusual. The third step, that is, suturing, he discusses in detail on account of the decisive influence on the outcome and ultimate issue of the whole operation. The placing of the conjunctival suture and cicatrix in a position favorable for recurrence is the paramount disadvantage of most of the methods in vogue for the extirpation of pterygium. Figure 390, 1, shows the conjunctival defect after excision of the pterygium. His method consists in suturing the conjunctiva, *B*, to the point *A*, with the episcleral tissue and conjunctiva

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[2] Zubac, Arch Ophth., May, 1931
[3] Trans Internat Cong. Ophthalmology, 1922

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[2] Zubac, Arch Ophth., May, 1931.
[3] Trans. Internat. Cong. Ophthalmology, 1922.

there, as is shown. Next the points *C* and *D* of conjunctiva are united by another suture. As it is easy to understand, the essential feature of this method is the insertion of a suture which is passed through the conjunctiva of one flap at a point *B*, and through the episcleral tissue and conjunctiva of the point *A*. The points *A* and *B* are equidistant from *Y*. Thus, when *B* comes to *A*, the tract *A–Y* is overlapped at that portion of the limbus, by *B–Y*. The point *B* is perfectly movable, because it takes the conjunctiva only, whereas the point *A* is quite steady and immovable by reason of comprising the limbus conjunctivæ and episclera as well. Occasionally, and especially in cases when the pterygium's head is large, it is advisable to undermine a little the flap *B* in order to avoid the stretch on this flap when *A* is anchored to *B*. On drawing the flap *B* to *A*, an actual overlapping of a portion of cornea may result; this, however, is quite uneventful, and on taking off the bandage in a couple of days' time everything

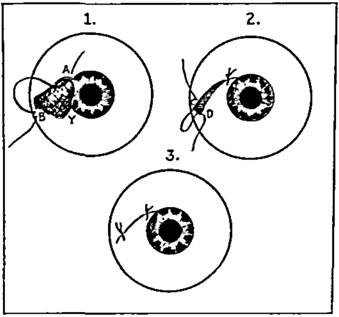

FIG 390 —Campodonico's technique for pterygium resection.

will be found in a perfect coaptation. Instead of making the lower flap movable and the upper one fixed, we may just as well do the reverse and anchor a loose point of the upper flap to the episcleral tissue and limbus conjunctivæ of the lower. This may be done in cases in which it is easier to loosen and slide the upper flap than the lower. The first way is preferred because the conjunctival seam is thus more efficiently protected by the agency of the upper lid from exposure. At the end of the operation it will be found also that fibers which had before a horizontal direction now have a vertical one; their natural trend of growing is consequently thwarted. A still further advantage in removing the conjunctival apposition line from the horizontal meridian is the fact that by so doing, we eliminate in the horizontal line the presence of sutures which undoubtedly act as a stimulus for reproduction of connective and fibrous cicatricial tissue, just exactly in a place where it is least desirable. The eye is bandaged for seven or eight

days, after which the sutures are removed. The bandage is changed every other day. *Whenever possible, it is a good plan to keep both eyes bandaged, at least for a couple of days.* The operation eliminates the big disadvantage in the ordinary excision method of pterygium operation: the placing of the conjunctival suture and cicatrix in the horizontal meridian, that is, in a position especially favorable for recurrence.

Arlt ablated a pterygium in a slightly different manner. He resected the entire pterygium so that a rhomboidal defect was present in the conjunctiva, one angle of the rhomboid on the area of corneal denudation, the opposite angle well into the internal canthal angle. His dissection started in the canthal angle and was completed by *tearing* the head of the pterygium from the cornea. A scalpel may be used for this, a suture, or a pair of straight blunt scissors, depending upon the extent of corneal involvement and the size of the head. In this operation, as in most pterygium operations, it is well to curet the position of the corneal head free of any residual pterygium tissue. The conjunctiva is closed readily, the two diverging incision lines from the cornea, being continued obliquely—one toward the superior cul-de-sac and the other toward the inferior cul-de-sac The entire conjunctiva is then undermined and the rhomboidal defect closed The two arms of the defect, which diverge from the caruncle, are first closed with a sufficient number of sutures to give accurate approximation. The two lesser flaps juxtacorneally are then subsequently closed without permitting any corneal overlapping by the conjunctiva. The result of the operation will give a crucial line of sutures, and dividing the conjunctival flaps in this manner permits very satisfactory closure. This operation can be utilized as well after removing any type of conjunctival neoplasm.

Beard's conjunctival plastic operation is rather similar to that of Arlt, except that after the head of the pterygium has been removed from the cornea, he continued his canthal incision in a vertical manner from cul-de-sac to cul-de-sac so that *the shape of the defect is roughly hemispherical.* The two flaps used to close the conjunctiva are outlined above and below the limbus as two crescentic finger flaps, one from above the limbus and directed toward the inner canthus, and the other from below the limbus directed upward toward the inner canthus. The writer feels that Beard's *operation is better applied for the removal of conjunctival tumors* and other similar conjunctival conditions rather than to true pterygia in that *the base of the pterygium is not resected, and this may be a disadvantage.*

Ziegler's subconjunctival excision of a pterygium is based upon his theory that a pterygium is a subconjunctival new growth, cicatricial in character, and possessing a tendency to undergo persistent contraction. The technique of his operation follows:[1]

Cocain is sufficient as an anesthetic, and adrenalin may be instilled as a hæmostatic. *The neck of the pterygium is grasped firmly with rat-toothed* fixation forceps, drawn tense, and the marginal fibers of the head freely divided with the back and point of a Beer's knife, used as a dull dissector. If the apex is unusually adherent, the knife may be passed beneath the neck, and the head shaved off (Fig. 391, *A*). Still grasping the apex and holding it tense, both sides of the pterygium are to be cut loose with scissors, the body undermined, and the flap lifted (Fig. 391, *B*). The forceps which

[1] *Proceedings International Congress of Ophthalmology*, 1922

grasp the apex are now handed to an assistant, who continues to hold the flap taut, while the subconjunctival tissue beneath the flap is grasped by a second pair of forceps and carefully dissected off from the conjunctiva by delicate snips with sharp-pointed conjunctival scissors (Fig. 391, *C*). When the conjunctival flap is freed from the underlying tissue, its apex is excised and the remaining flap of pure conjunctiva dropped back toward the canthus. If the pterygium is small, the conjunctival wound is to be closed by two sutures, the juxtacorneal one being anchored in the sclera. This may cause overlapping of the corneal margin, which is corrected by clipping the cuff-like roll of conjunctiva in several places with scissors and pushing it back. As the conjunctiva again smooths out, these "pie-cuts" open into small diamond-shaped perforations which relieve all tension and heal smoothly (Fig. 391, *D*). If the wound is larger and the conjunctival tension is great, two short 5 mm. paracorneal incisions are made, above and below the conjunctival edges, undermined, and the wound united by

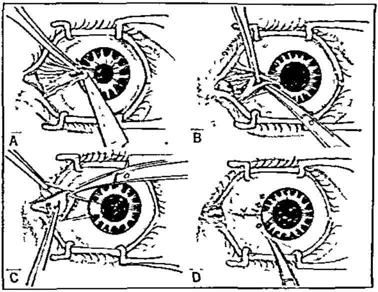

FIG. 391.—Pterygium resection. (Ziegler.)

two sutures, the juxtacorneal one being anchored in the sclera. If the denuded area is extremely large, two sets of liberating incisions are made, the paracorneal incisions above and below being supplemented by incisions made parallel to the first (5 to 10 mm.) and placed at the canthal extremity of the wound The quadrilateral flaps thus formed are closed with three sutures, the juxtacorneal one being anchored in the sclera, and a mattress anchor suture placed at the canthal intersection, as in Knapp's double transplantation.

As a rule, the simple technique of the first procedure is wholly adequate to close the wound. Healing is smooth and prompt, owing to the avoidance of extensive dissection and the freedom from tension. A monocular dressing is applied for three or four days. The stitches can be removed on the third or fourth day. Boric acid irrigation is used once daily until the pad is discarded, then three times a day. The eye usually remains red for one or two weeks.

The simplest form of transplant for pterygium is that of the McReynold's technique. The head of the pterygium is grasped with a forceps and removed from the cornea either with a sharp scalpel, with a keratome, or by forcibly tearing it from the cornea. The area occupied by the head of the pterygium should be carefully curetted and the pterygium freed to its base. The sides of the pterygium are thus incised with a short incision above and a longer below. The conjunctiva below the lower of the two incisions is then well undermined. A double-armed mattress suture is placed through the head of the pterygium and the two needles passed into the pocket formed beneath the conjunctiva, by its undermining, and the ends of this suture brought out near the lower cul-de-sac. As these two ends of the suture are being tied the conjunctival lip is raised with forceps and the pterygium, by this suture in its head, drawn downward into this pocket. Figure 392 illustrates the technique. A second suture is usually necessary to complete the closure of the conjunctival defect at the limbus

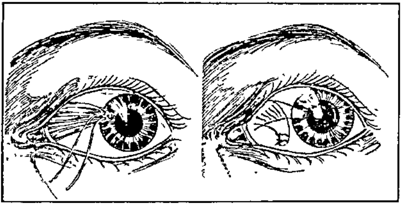

FIG 392 —McReynolds' transplant.

Desmarres and Knapp carried out their transplants somewhat differently In both of these operations the elevated pterygium may either be buried under the conjunctiva as in the McReynolds' technique, or the pterygium itself may be transplanted as a pedicle flap away from the limbus and directed above or below toward the superior and inferior cul-de-sacs. Figure 393 illustrates the technique. The pterygium is elevated in the same manner as one would do for a McReynolds' transplant. The two diverging incisions which outline the pterygium are about the same length, however, and from the extremity of the lower ot the two, a third incision is carried toward the inferior cul-de-sac. The conjunctiva is then undermined above and below. The small flap is then sutured juxtacorneally, and the head of the pterygium is sutured as illustrated. Terrien carried out his dissection in the same manner, but he buried the pterygium under the conjunctiva, as is done in a McReynolds' transplant, and then closed the conjunctiva by bringing the quadrilateral flap formed, upward, as in Figure 393, C. Either of the two is quite satisfactory.

Desmarres' original operation undoubtedly preceded the McReynolds technique. This operation, however, permitted a denuded area at the original site of the pterygium to heal in by granulation, a condition not surgically sound.

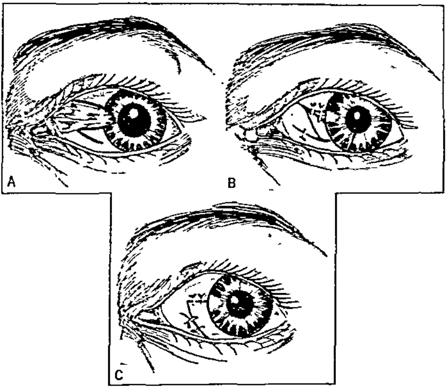

Fig. 393.—*A* and *B*, Desmarres' technique for pterygium transplant; *C* is Terrien's modification

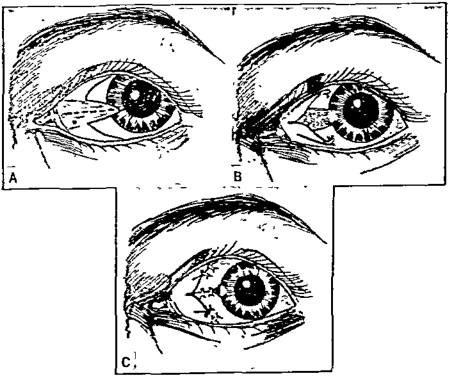

Fig. 394.—*A* and *B*, Knapp's technique for pterygium transplant; *C*, Terrien's modification.

In Knapp's operation, which is especially applicable to a pterygium with a broad head, the pterygium is split into two halves, by a central horizontal incision, as in Figure 394. Lateral incisions are then made in the conjunctiva from the extremities of the two incisions which outline the pterygium as a

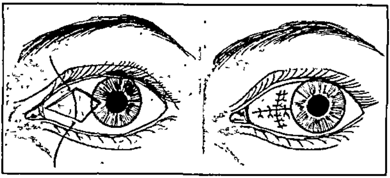

Fig. 395.—Arlt's pterygium operation

movable flap. Each half of the pterygium, as seen in *A*, is then sutured as in *B*. In this way the pterygium tissue is moved from the limbus and utilized as conjunctiva. Terrien disposes of these two flaps by burying them under the conjunctiva as mentioned in the Desmarres technique. He then closes the conjunctiva with his quadrilateral flaps, as seen in *C* of

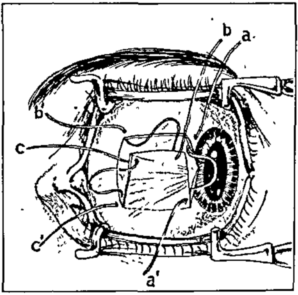

Fig. 396.—Author's conjunctival rotating island flap for pterygium.

Figure 394. Arlt's technique of a spindle-shaped resection and a crucial incision closure, shown in Figure 395, is ideal for an early stationary (?) pterygium.

In 1926, the author[1] described his rotated island graft for pterygium.

[1] Am Jour Ophth, vol 9 No 9, September, 1926.

This is based upon the formation of a rectangular island of conjunctiva, including the pterygium, which is rotated 90 degrees upon itself. The subconjunctival tissue still adherent to the island is not resected, however, from the episcleral tissue. It is particularly applicable for a large pterygium or for a recurrent pterygium, especially when there is some limitation of conjunctiva already present in the case.

Cocain instillation is sufficient for the operation. A sharp probe is passed under the head of the pterygium, a stout silk suture threaded through this perforation, and the head torn from the cornea with this suture assisted by forceps. Careful curettage is then done of the area of the corneal attachment, using a sharp spoon curette. A perpendicular tangential incision is continued in this line of divulsion, above and below, a total length equal to the width of the base of the pterygium. A braided black silk suture (Fig. 396) is then passed through the fixed conjunctiva at the upper extremity of the incision, in its outer lip, and near the cornea, including a bit of the episcleral tissue: the loop carried across the pterygium and passed into *the conjunctiva through the inner movable lip of the lower extremity of* this incision. The loop is then drawn away from the operative field.

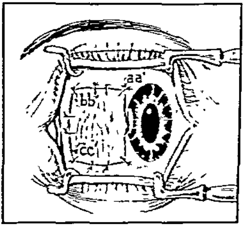

FIG. 397.—Sutures at completion of operation. (See text.)

A second incision is then made from the upper end of the first, horizontal, and hence at a right angle to it, toward the canthal angle. If the length of the first incision has been properly made this horizontal incision will include the upper edge of the pterygium, back to its base. Suture *b* is then passed from the inner extremity, fixed upper lip, of this incision, across the length of the pterygium into the upper movable outer angle of conjunctiva outlined by and within these two incisions. The loop of this suture is also withdrawn from the operative field.

A third incision, this time perpendicular, is made from above downwards across the base of the pterygium, paralleling the first and of similar length, starting at the inner extremity of the upper horizontal incision just explained. The incision must lie external to the caruncle and should include sufficient subconjunctival areolar tissue to allow for the later rotation of the pterygium. Experience will tell this, though the more incised, the more satisfactory and rapid the recovery. The tissue must be incised, including

all subjunctiva, but without incising the internal rectus muscle. Suture *c* is then passed from the angle at the fixed inner lip of the lower extremity of this last incision across the width of the base of the pterygium into the upper, movable inner angle of bulbar conjunctiva outlined by this last incision and the one immediately preceding. When this last cut is made, some bleeding will occur. This can be stopped by slight pressure with a dampened gauze sponge.

Single loose ties are then to be made in each of the three sutures, largely to move the loops from the possibility of being unintentionally cut.

The cut shown by the dotted line is now made. This should be of the same length and parallel to the upper horizontal incision. Also it must lie outside the flap or island graft insertion of *a* suture. As this cut is completed a square "island graft" is outlined, attached to the eyeball only by the uncut subconjunctival areolar tissue beneath it, and perhaps by some loose uncut subconjunctival areolar tissue at the inner canthus. Sutures *a*, *b* and *c* are then tied and their ends cut short. As these are tied the pterygium, now within the outlines of the graft, is rotated 90 degrees. The head points toward the upper cul-de-sac and the base lies within the lower cul-de-sac, if the incisions have been made of the proper length, and the sutures properly placed into the surrounding conjunctiva.

A last suture is then placed through the bulbar conjunctiva at the lower end of the first perpendicular incision and then into the corner of the rotated graft now lying in the angle formed by the first and the last incisions. The suture should include some episcleral tissue, the same as the first, and should hold the outer juxtacorneal edge of the rotated graft rather taut, tangentially, to the cornea. It must not allow the edge of the graft to extend over upon the cornea. It is better to have a fine linear uncovered defect present, between the edge of this graft and the corneal epithelium defect, caused by the divulsion of the head of the pterygium from the cornea and the subsequent curettage.

Additional sutures are then placed in the center of the upper and the lower horizontal incisions, and another, if necessary, into the center of the perpendicular canthal incision. The first two will be necessary in most cases. If there is any difficulty in freely rotating the graft, it may be necessary to introduce blunt scissors beneath the graft and to cut some of the subconjunctival tissues, until this is possible; no more should be cut than is essential.

A binocular dressing is used, regardless of whether the operation is monocular or binocular with some slight pressure upon the operated eye. It has a tendency to keep the eye quiet and motionless. The patient is put to bed and the dressing not disturbed for seventy-two hours. After that the bandage may be removed, the lid margins gently separated, and the cul-de-sac cleansed with a quiet stream of warm boric acid solution. Additional bichloride ointment is placed upon the lid margins and a second monocular dressing applied for another seventy-two hours. At the end of that time the sutures may be removed and the patient allowed to go without a dressing; though tinted glasses will be restful, because some slight photophobia is usually present.

The success of the operation seems to depend upon three factors: the first is the fact that the direction of the fibers of the pterygium is now changed from their original horizontal to a perpendicular course; the second depends

upon the atrophy of these fibers and the blood-vessels, with scar tissue replacement and deposition, and the prevention of the later development of pterygium through this network of connective tissue fibers; and the third is because of the rectangular scar, the two vertical lines being the most important, these now lying interposed between the canthal angle and the corneal limbus, that is, in the path a recurrent pterygium would have to take.

Figure 398 illustrates one of bilateral pterygia of the right and left eye, the type of case which is well corrected by this technique. In 1932, Blott[1] modified this technique by rotating the island of conjunctiva 180 degrees instead of 90 degrees, in this way placing the head of the pterygium toward the inner canthus with a base now parallel to the limbus. Shainfein[2] also called attention to this, except in his technique he transplants the split apex of the pterygium subconjunctivally toward the canthus, hence well away from the cornea.

FIG 398 —One eye of bilateral pterygia of almost malignant proportion

Recurrent pterygia with extensive loss of conjunctiva need a mucous membrane graft for their correction. In these cases, after resection of the pterygium, the conjunctival adhesions are incised in a T-shaped manner, the T lying upon its side with the shorter bar at the limbus, the longer branch extending well into the canthal angle. The conjunctiva must be well undermined and displaced upward and downward, until the lower cul-de-sac is well reformed and without tension in the cul-de-sac. It may be necessary to pass several mattress sutures through the depths of the new cul-de-sac formed to the skin surface, these tied through pearl buttons. A thin buccal mucous membrane graft is used to cover the conjunctival defect resulting from this dissection. This may be sutured into place, though a conformer is also necessary. The graft must be accurately measured, and the sutures hold it without undue tension but with adequate tautness. If the graft is unnecessarily large it will contract and remain thick. Sufficient sutures should be placed so that accurate coaptation is obtained to the contiguous conjunctiva and to the underlying episcleral tissue at the conjunctival edges. The defect, which must be filled in will be rather triangular in shape. A binocular dressing, with pressure over the operated eye, must be used.

Conjunctival Cysts.—The consideration of these, at this point, does not *include conjunctival cysts* which develop in the anterior chamber, and which follow traumatisms, with perforation of the eyeball, and as after inter-ocular surgery. Serous cysts of the conjunctiva are not uncommon. See Figure 399. They probably cause few symptoms if the patient is unaware of their presence, for frequently small serous cysts of the conjunctiva are discovered, during routine ophthalmologic examinations, without the

[1] Ztschr f Augenh., January, 1932.
[2] Klin. Monatsbl f. Augenh, 92, 190, February, 1934.

patient having been aware of their presence. If surgical removal is necessary, cocain installation and the cautery will take care of smaller cysts. Larger serous systs are seen usually in the inferior cul-de-sac and toward the external angle. Some of these cases have a vague history of pre-existing trauma, perhaps not at all relevant but at times significant. The greatest the author has even seen was one which followed the external margin of the inferior rectus for at least 2 cm. into the orbit. Dermoid oil cysts have been seen and described in the superior cul-de-sac, oftentimes so extensive that there is an atrophy of the bone at their base. Incision of the overlying conjunctiva and removal of the cyst sac are necessary. Echinococcus cyst of the conjunctiva has been described. The diagnosis of these, however, is made at the time of the evacuation of the cyst contents. Subconjunctival filaria have also been seen and diagnosed. The surgical removal of the first must be done. The removal of the second would be a clinical rarity and undoubtedly of great interest.

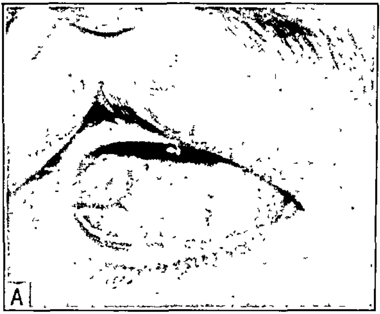

FIG. 399.—Benign cyst of the conjunctiva

Benign Papillomata.—Benign papillomata and polypi are the results of chronic irritation, apparently, and are seen not uncommonly in the incision lines of the conjunctiva, especially following muscle surgery. They must be removed at their base and cauterized either with a 5 per cent silver nitrate solution or with the actual cautery. These bleed rather readily and oftentimes are accompanied by some chronic suppuration. Melanomata, which are benign pigmented growths, usually occurring in the uveal tract, have been reported in the conjunctiva. Zentmayer showed to the author one such case of bilateral superior conjunctival or cul-de-sac melanoma which had become recurrent. Pathologists still have differences of opinion about these in regard to their origin. They are either mesoblastic or epiblastic, that is certain. Their appearance is rather like that of old, dark brown, clotted blood, and the overlying conjunctiva is thrown into folds

and rugæ. In view of the fact that these may be or become malignant, they should be removed and treated with roentgen-ray therapy. (See section on Irradiation Therapy.)

THE RESULTS OF CHRONIC INFLAMMATORY DISEASES OF THE CONJUNCTIVA

Trachoma.—In considering the acute phase of trachoma from a surgical standpoint, the author has already expressed himself adequately. MacCallan[1] from his own extensive personal experience, is still quite unconvinced that the sulfa drugs have any definite therapeutic effect upon the specific lesions of trachoma. "The satisfactory effect of the sulphonamides on the secondary bacterial complications of trachoma, ... is indisputable." MacCallan states, further, "The third stage of trachoma is characterized by beginning cicatrization while retaining many signs of the second stage. (The second stage is characterized by the presence of numerous bleb-like excrescences which rupture on pressure with the escape of gelatinous material consisting of broken-down cells.) . . . . such cases in the third stage often experience much relief from sulphonamide medication though the trachomatous lesions are unaffected." MacCallan was unable to comment upon the use of the sulfa drugs in the very recent acute phase of trachoma, but he felt that the second stage of trachoma, like the third stage, was also unaffected in so far as the trachoma lesions was concerned. Recently (during the past three years) in 32 to 172 consecutive cases of trachoma he (MacCallan) found it necessary to resect a thickened and diseased tarsus with the overlying conjunctiva, and in 37 others from this same series, to express the amorphous mucoid material from the bleb-like swollen follicles.

According to Lennette,[2] the results obtained in sulfanilamide therapy in virus diseases have been disappointing. This is not surprising, however, since at present the sulfanilamides in tissue culture have been found to have no appreciable effect on the multiplication of any of the virus cultivated in such an environment.[3] Of the diseases usually classed with those of virus origin only four, trachoma, inclusion blenorrhea, lymphogranuloma venereum, and mouse pneumonia are known to respond to sulfanilamide therapy. Rake, Jones and Nigg[4] do not believe that the success of therapy in these four virus diseases has any bearing on the chemotherapy of the true virus disease, since there is increasing evidence that the causative agents of at least the lymphogranuloma venereum—psittacosis group diseases (to which these four belong,[5]) should be separated from the true viruses. Further, Sanders and Alexander[6] isolated a virus from epidemic kerato-conjunctivitis from tissue culture which they proved to be pathogenic to men, mice and rabbits. The association of their virus with the human disease known as experimental kerato-conjunctivitis, appears thereby to be established. Clinically, the sulfanilamides have been no

[1] Trans Ophth Soc. United Kingdom, 62, 38-39, 1942.
[2] Science, Nov 12, 1943, Vol. 98, No. 2550, Pub. Inter. Health Div. of the Rockefeller Foundation.
[3] Sanders, Huang and Simms, Jour Bacteriol., 45, 81, 82, 1943
[4] Rake, Jones and Nigg, Proc. Soc. Exper Biol and Med., 49, 449, 1943.
[5] Rake, Shaffer and Thygeson, Proc. Soc. Exp. Biol. and Med., 49, 545, 547, 1942.
[6] Sanders and Alexander, Jour. Exper. Med., 77, 71, 1943

more successful in the treatment of this condition as in the other virus diseases. This should answer many queries relative to the surgery of subacute trachoma, though it is at variance with opinions hitherto expressed in American and European medical journals.

The cicatricial stage of trachoma is essentially a surgical problem. The bulbar conjunctiva, the palpebral conjunctiva, and the lids with their lid margins, all offer individual and separate problems. The practical factor relative to the bulbar conjunctiva is the treatment of pannus. This pertinacious vascularity of the superficial portion of the cornea oftentimes, in spite of the best medical treatment possible, seems to advance steadily, to become thicker progressively, and to seriously endanger the possibilities of recovery. If the palpebral conjunctiva (the cul-de-sacs and the tarsal plates) shows great pathology, this must also be corrected, in addition to those measures which are applied to the bulbar conjunctiva itself. The thermophore may be used in these cases of low degree invasion, but it will not be of value in cases which have advanced to surgical proportions. Peritomy and peridectomy are procedures, based upon sound surgical principles, and these operations should be used when indicated. There has been much controversy relative to them by eminent men who have spoken both pro and con, but they have given the author full satisfaction whenever used. Pathology of the cul-de-sac must be simultaneously, if not previously, corrected. Furthermore, these malignant forms of pannus, known by various authors as pannus crassus and pannus sarcomatoid, do not lend themselves well to peridectomy alone. They must be combined with pericorneal cautery; Beard speaks of this additional assistance as igneous peritomy.

Peritomy itself is the incision of the conjunctiva peri-corneally, using small, pointed, curved scissors. Cocain anesthesia is adequate, and one must be certain that the conjunctiva is cut as close to the limbus as is possible. A small curet is used; with this, the severed conjunctiva is *moved back from the limbus and the episclera curetted until the sclera is* quite bare. If necessary, the cautery is then used, also lightly applied, to the superficial layers of the sclera, especially in the upper limbus. Before the dressing the eye should be well cleansed of all blood clots. Bichloride ointment may be instilled in the cul-de-sac and a dressing applied for twenty-four hours. After reaction has disappeared, irrigation and hot compresses are used if necessary, to give the patient comfort. Peridectomy is the same as peritomy, except that a narrow strip of conjunctiva is resected from the juxtacorneal conjunctiva, to increase the space between the limbus and the retroplaced conjunctival edge. The strip resected should be about 2 mm. in width. In cases of pannus of severe degree, it is wise to combine the peridectomy, in the upper half of the limbus, with cautery. In pannus crassus, which has advanced upon the cornea above the level of the normal epithelium, the cautery may be applied directly to the pannus tissue.

Oláh[1] feels that trachoma of the lacus lacrimalis and in the medial angle over the caruncle needs special surgical treatment, that it is most resistant to all forms of treatment, and further, that it continues to develop here even when the remaining portion of the conjunctival involvement is on the

[1] Arch. Ophth., vol. 24, No. 4, October, 1940.

mend. He definitely states that the lateral angle reacts quite differently: "I have as yet not found a case in which the trachoma was localized in the external angle after the rest of the conjunctiva was healed."

This condition, encanthis trachomatous, is operated by Oláh as follows: After the lids have been drawn apart, a vertical incision is made 1 cm. in length in the conjunctiva medial to the plica. Two sutures are placed into this incision, and while holding them taut, the conjunctiva is undermined to permit the introduction of one blade of the trachoma expressing forceps beneath the conjunctiva. The follicles are then expressed with this from the plica and the caruncle. The sutures are then tied there after the expression.

Ectropion, Entropion, Trichiasis, Symblepharon Posterioris (of trachoma) have been previously discussed. The most common defect seen is ectropion of the lower lid combined wth entropion of the upper lid. A certain amount of ptosis is also present and the conjunctiva of the lower lid is usually quite thickened and shrunken. A tarsus resection will correct the ptosis at the same time the pathology of the palpebral conjunctiva is corrected in the upper lid. If at this time one sees that the entropion present in the upper lid is going to fail of correction, Lyritzas' technique for entropion and trichiasis in trachoma may be utilized.[1] A horn plate is inserted between the eye and the inner surface of the upper lid. Two transverse incisions are made through the skin parallel to each other, one being close to the lid margin, the second 3 mm. from it. The strip of skin between the two is removed. Five mattress sutures are placed, one in the mid-line and the others equidistant from it. The two ends should be passed from the ciliary margin through the muscle over the tarsus, and then through the upper margin of the skin incision. They may be removed at the end of a week. The van Milligan technique for lengthening the palpebral conjunctiva surface by means of a mucous membrane graft is also a quite satisfactory procedure.

The lower lid deformity must be corrected by a cul-de-sac and tarsus resection with suture. In this operation the inferior cul-de-sac should be ballooned out by the injection of novocain and adrenalin, the skin surface also anesthetized, and the infra-orbital nerve blocked at its foramen. Two temporary marginal sutures, to be used as traction sutures, will facilitate the operation decidedly. The first incision is to be a horizontal incision parallel to the lid margin and about 2 to 3 mm. from it. The incision is deepened, the tarsal plate grasped with a forceps at the mid-line, and freed from the overlying fascia and orbicularis fibers. The lid margin is held downward by the traction sutures and, with sharp dissection, this tarsal plate is resected from the cul-de-sac with any adherent pathological conjunctiva overlying it. *If adequate healthy conjunctiva remains, sufficient* to correct the ectropion and permit movement of the eyeball within the orbit, well and good; if not, a mucous membrane graft must be utilized to restore the resected cul-de-sac. In the case of the first possibility, mattress sutures are passed from the edges of the intact bulbar conjunctiva to the marginal lip of the first incision made. Three double-armed mattress sutures are then passed from the mid-line of the new cul-de-sac, downward and outward, emerging upon the skin surface, according to Arlt's technique

[1] Arch. f. Augenh., 108, 339, December, 1933.

for symblepharon, to reëstablish a fornix. These sutures are tied through pearl buttons. The traction sutures originally introduced are used as a part of the dressing to raise the level of the lower lid during healing; they are carried upward and attached to the forehead by adhesive strips.

Vernal Catarrh Excluding Radium Therapy.—Vernal catarrh is not essentially a surgical condition. The author feels that he has assisted his cases, however, most decidedly by electrocoagulation with unipolar diathermy current carried out during the cold months of the year. (See also Cul-de-sac Resection, page 356.) At this time the patient complains of but few subjective symptoms, and the case is at maximum quiescence. The treatment is a hospital procedure. Cocain is instilled and the superior cul-de-sac ballooned out with a novocain and adrenalin subconjunctival injection. The lid is then everted, and with a unipolar electrocoagulation diathermy needle each hob-nailed hypertrophied papilla is carefully desiccated with the needle. Both upper lids may be done at one operation as well as the electrodesiccation of any limbal or bulbar papillæ which may be present in the case as well. At the close of the operation, boric acid ointment, U. S. P., is placed into the cul-de-sac, and the eyes closed and not dressed for the first twenty-four to forty-eight hours. The operative reaction is not marked, and after the first dressing the patient may leave the hospital. In each instance in which this was done, the following season of vernal catarrh was much less severe in its intensity, and the patient had considerably more comfort. The other forms of medical treatment and the investigation of allergic possibilities in any one case cannot be neglected. Lehrfeld's treatment with a 1 per cent solution of sodium monocarbonate and irrigations with iced boric acid solution seems to be fairly satisfactory in most instances.

Pemphigus, or Essential Shrinkage of the Conjunctiva.—This condition can be corrected with mucous membrane grafts. Severe xerosis of the conjunctiva with its sequelæ are not permanently assisted, in the writer's experience, by mucous membrane grafts. Often these cases are seen well advanced to such a grave degree that surgery cannot offer any hope for improvement of vision. Any other attempts to halt the progress of essential shrinkage, by incision of the conjunctiva, by resection of cicatricial bands, or by the introduction of conformers, are fruitless.

Calcareous Concretions.—Calcareous concretions in the conjunctiva often cause considerable distress. The conjunctiva should be cocainized and the concretions removed with a tiny curet.

Tuberculosis.—Tuberculosis of the conjunctiva occasionally assumes the proportion of a malignant granulation. It suppurates; there is constant lacrimation and considerable pain. One case developed following the subconjunctival injection of atropine, and clinical examination failed to show any other source for it; another case, seen in consultation, followed a traumatic superficial keratitis. In each instance, resection of the granulomatous mass, followed by tuberculin treatment resulted in a good recovery.

Ophthalmia Nodosa.—This condition occasionally may be confused with trachoma or vernal conjunctivitis. According to F. Knapp[1] Pagenstecher described the condition in 1883, though Saemisch first gave the condition that name by which we call it. It is due to the accidental introduction of

[1] Arch. Ophth., vol 24, No. 3, September, 1940.

caterpillar hairs in the conjunctiva, resulting in a chronically inflamed palpebral *conjunctiva*, showing many small yellowish nodules upon a mildly hyperemic palpebral conjunctiva. The nodules are irregular in shape and

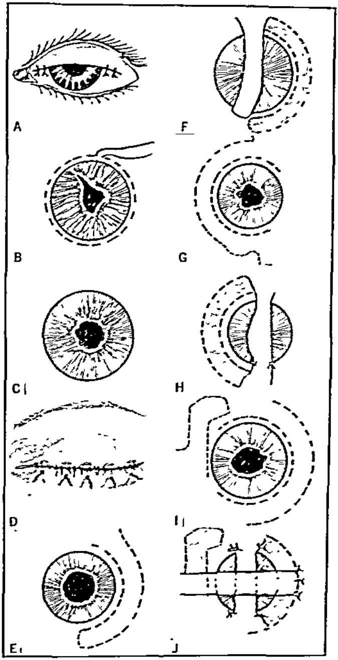

FIG 400 —Various conjunctiva plasties, *A*, simple van Lint flap; *B*, purse string suture; *D*, temporary tarsorrhaphy as for central perforation as in *C*; *E*, *F*, *G*, and *H*, pedicle flaps; *I* and *J*, bridge flaps.

in size, though with even edges. Verhoeff feels that any type of plant hairs also, may be commonly the cause for the condition. Knapp recommended the injection of a 1 to 1000 solution of mercury oxycyanide, repeated

injections being carried out in the vicinity of the nodules, only enough being used to make a small bleb each time. He repeated the injections eight or nine times at intervals of three days.

CONJUNCTIVAL PLASTICS

The conjunctiva as such, or in the form of conjunctival flaps of various forms is an invaluable means for the correction of various pathological conditions of the globe which undoubtedly would result in the loss of the globe, were not this means available. Iris prolapse resulting from perforating wounds of the globe and following as a complication after intra-ocular surgery; gaping incisions after cataract extraction; corneal ulcers, especially those accompanying keratitis paralytica; in operations for juxtalimbal staphylomata; and more recently in keratoplastic transplants for corneal plastics; the conjunctival flap of some type is one of the most important features. Practically all of these procedures can be done under 4 per cent cocain instillations, assisted by a subconjunctival injection of novocain with adrenalin. The injection actually assists in the elevation of a sac by ballooning out the subconjunctival space. The condition demanding correction decides the type of flap one should use. An iris prolapse following a cataract operation or with a perforating wound near the limbus is best corrected, after the necessary iridectomy and toilet of the wound has been done, with a simple van Lint flap, as illustrated in Figure 400, *A*. In this the flap is to be cut from the superior limbus and elevated by blunt and sharp dissection until it can be moved well down past the mid-line of the cornea. Two sutures are placed from the lip of the conjunctival flap to the conjunctiva, laterally and medially to the limbus. While these are being tied, an assistant should pass an iris spatula beneath the flap to assure the operator that the cornea is lying smoothly beneath the flap. Additional sutures may be placed as is necessary, all of the sutures to take generous bites of its conjunctiva. A too-early release of sutures, either by accident or deliberately, is to be guarded against. A central corneal perforation is best protected by a full purse-string suture as outlined in Figure 400, *B*, or by a conjunctival flap from above and below the limbus, as in *E*. The sutures in *H* should be mattressed through from the upper lip to the lower lip, so that the conjunctival edges will evert, and at the same time prevent contact to the cornea with the sutures. Corneal ulcers, if near the limbus, can be protected and their healing more nearly assured, if a pedicle flap as outlined in *G* and *H* is used. Large corneal ulcers, especially those accompanied by a keratocele, should be operated by a combination of pedicle flap with a bridge flap. The bridge flap, *I* and *J*, however, should lie beneath the pedicle flap, for the latter of the two furnishes the major portion of the necessary tension in cases for which this procedure is being used. The bridge flap is simply protective to the corneal pathology and cannot, of itself, exert tension. In all of these instances, wherein a conjunctival plasty is being used, the sutures may be removed after eight to ten days, unless they have extruded themselves spontaneously.

CHAPTER XVI

SURGERY OF THE SCLERA AND THE CORNEA.

THE SCLERA

SURGICAL conditions of the sclera are those connected with perforating wounds of the sclera, with posterior sclerotomy as used in certain forms of glaucoma, the scleral approach for the treatment of retinal separation, and *scleral resection in an attempt to halt the progress of progressive malignant* myopia. Scleral staphylomata and scleral ectasia when present are more likely an indication for enucleation rather than for any other surgery upon the sclera. Posterior staphylomata, the scleral approach to retinal separation, and the scleral resections for myopia, will be discussed under these subdivisions.

WOUNDS OF THE SCLERA

Wounds of the sclera which pass across the danger zone of the ciliary body up to the cornea and into the cornea are always to be considered as cases in which sympathetic ophthalmia may develop. No person will find fault with a recommendation for enucleation in extensive wounds of this region as long as the patient has an unimpaired and undamaged eye in the opposite orbit. It is well known that sympathetic ophthalmia, when once established in the opposite eye, is too likely to progress to such a degree that the originally injured eye may be the better of the two when the case has finally become quiescent. As all scleral injuries crossing the ciliary *body do not develop sympathetic ophthalmia, it is permissible to temporize* (in so far as an enucleation is concerned) in minor injuries of the sclera, after the immediate repair surgery has been carried out, and to keep such cases under close observation before proceeding to more radical surgery. Certainly, however, in the extensive injuries of the sclera when accompanied by prolapse of the ciliary body, by hæmorrhage into the vitreous, by prolapse of the vitreous, by hæmorrhage into the anterior chamber, by an extrusion of the lens subconjunctivally (one or more of these), that immediate enucleation is indicated. The vagaries of sympathetic ophthalmia are well known. Extensive injuries have been repaired, and eyes saved with good and even normal visual acuity resulting. On the other hand, very minor injuries of the globe have resulted in bilateral blindness.

Sutures into the sclera itself are not always introduced in minor wounds of the sclera, but prolapse of the uvea or of the vitreous must be cleanly resected. Such injuries, at the time of the original repair, should be rimmed about with an encompassing circle of diathermy micro-cautery punctures. The incidence of late retinitis proliferans is cut down thereby, and the development of late retinal separation is *undoubtedly prevented in the* greatest proportion of such cases. A vitreous fistula may develop if the wound edges do not approximate; therefore angular incision wounds must be sutured. Crescentic wounds not only gape, but often the two lips of the wound are unequal in level. Scleral wounds, when sutured, are best closed with No. 6-0 plain catgut suture. The needle should not perforate the sclera, but only penetrate the superficial sclera, or perhaps one-half of its

thickness. It is important to prevent capsule, fibrin, uvea, vitreous, or clot from lying between the lips of the wound. The overlying conjunctiva is to be closed with black silk in such a way that the conjunctival incision is displaced from the scleral wound. Scleral wounds, if not originally infected, heal readily. The distressing point of these injuries is their subsequent effect upon the integrity of the retina. For this reason emphasis is again placed upon the fact that scleral wounds posterior to the ciliary body should be treated with micro-cautery needle punctures at the time of the repair (Walker needles for the diathermy treatment of retinal separation). Scleral wounds, in the region of the ciliary body, are of grave prognostic import, demand keen judgment in their handling, and if the eye is not to be enucleated as an immediate procedure, very careful detailed and frequent postoperative slit lamp studies are necessary. Personally, the writer would prefer the stigma of a possible unnecessary enucleation rather than experience a case of sympathetic ophthalmia developing as the result of his judgment in handling the case.

Subconjunctival rupture of the sclera from a direct blow may be so masked by conjunctival edema that ocular hypotension and vitreous chamber hæmorrhages are the only signs suggestive of the damage.

ECTASIA OR STAPHYLOMA OF THE SCLERA

Ectasia of the sclera may be divided into anterior equatorial, and posterior ectasia. Fuchs also speaks of a total ectasia consisting of a uniform dilation of the entire sclera so that the eyeball *in toto* is enlarged Total ectasia may occur, with a staphyloma of the cornea, with an extraordinary increase thereby in the size of the eyeball. Congenital or juvenile buphthalmos may be considered as a total ectasia.

Posterior ectasia of the sclera are not remediable to surgical treatment. Total ectasia or buphthalmos will be discussed under glaucoma. A hydroophthalmos, *that is, total ectasia, develops only in youth, because the sclera* of the adult is so rigid that anterior and equatorial staphylomata would develop instead. A posterior staphyloma will cause a considerable increase in myopia without, however, as Fuchs states, "inducing an elevation of tension and other deleterious consequences of anterior and equatorial staphylomata." Anterior staphyloma and especially corneo-scleral staphylomata with secondary glaucoma may be improved in some instances by an iridectomy, or by a corneo-scleral trephining, if still technically possible. In general, however, this type of staphyloma results from the interposition of iris between the cornea and the sclera, with the development there of a posteriorly pigmented, thinned out, prominence. An elevated intra-ocular pressure is always present. This may be the cause for the development of the ectasia. This is especially so with the equatorial staphylomata which develop usually about the entrances of the vortex veins In other instances, especially those which occur as a result of perforating injuries near the limbus, the glaucoma is secondary to interference with infiltration. The diminished resistance of the sclera, in these instances, could not stand even the normal intra-ocular tension and, with the rise of intra-ocular tension, as the result of the secondary glaucoma, a vicious circle is established which makes enucleation necessary, because of the disfigurement or because of the pain present.

SCLEROTOMY

Anterior and Posterior Sclerotomy.—Sclerotomy is considered under the surgery of the glaucoma. The sclerotomy of cyclodialysis is also considered separately. Anterior and posterior sclerotomy are so named as applying to the position of the scleral incision, that is, anterior or posterior to the ciliary body.

Anterior sclerotomy has been presented from time to time, by various authors, with varying modifications, as an operation for glaucoma. The principles upon which the operation was based depended upon the formation of a filtering cicatrix. There is no doubt that much of the value which was ascribed to the operation depended upon the anterior paracentesis obtained, not upon the formation of any filtering cicatrix. For many years the sclerotomy incisions of de Wecker, of Panas, of Galezowski, and of others, were rather common procedures. There is no doubt that their various procedures modified and inspired much subsequent glaucoma surgery, but the operation of a simple anterior sclerotomy has quite properly fallen into disuse If an anterior chamber drainage is desired, paracentesis through the cornea is just as satisfactory and probably has some advantages over those of an anterior sclerotomy. Posterior sclerotomy or posterior scleral puncture has value as an operative procedure. Its disadvantages are two-fold: the first, relief from it can only be temporary; and second, the operation itself may result in hæmorrhage. If the hæmorrhage were wholly extra-scleral it would be of no great clinical importance. A retinal or vitreous hæmorrhage, however, may occur and result in proliferating retinitis with separation of the retina or even a separation of the retina without pre-existing proliferating retinitis. The operation, however, has been frequently of value, especially in acute sudden hæmorrhagic glaucoma, and more rarely as a measure preliminary to other surgery in the presence of a very high ocular tension with simple non-inflammatory glaucoma. In such instances a posterior sclerotomy would be done twenty-four hours prior to a corneal trephining. The benefits derived from a posterior sclerotomy in acute hæmorrhagic glaucoma are likely due to the relief of the intra-ocular pressure for a time, sufficiently long, to permit the ocular fluids to again re-establish their normal drainage, to relieve the edema of the vitreous, and to allay the pain resulting from the acute hypertension. The above results develop rapidly, and after the scleral paracentesis, the temporary or transient relief of pressure which the operation gives is usually sufficient.

Posterior sclerotomy has been done for retinal separation, but the operation alone has no value in this condition. L. Müller's[1] crescentic sclerectomy had some fair success, however. He resected a strip of sclera, extending from the attachment of a rectus to the posterior pole of the eye, 10 mm. in width and about 20 mm. long. After the removal of this strip of sclera, sutures were introduced, and before they were tied, the choroid was punctured to permit drainage of the subretinal fluid. The operation is not recommended in view of modern separation surgery; as it now exists, and considering other factors connected with separation of the retina, a vitreous fistula through the sclera is a more logical procedure than a simple posterior

[1] Klin. Wchnschr., Vienna, April, 1903.

sclerotomy. Hæmorrhage should not occur, and filtration with release of inter-ocular pressure will continue for considerably longer. According to Lindner, it is also a logical procedure as part of the diathermy treatment for bullous separation of the retina.

Cocain anesthesia is usually sufficient for performing a posterior sclerotomy. In a case of severe hæmorrhagic glaucoma, the pain present may demand general anesthesia. The technique of the operation itself is not difficult. One must, however, avoid injuring the vortex veins, and naturally the ciliary body should also be spared. If the incision is made 15 mm. back of the corneal limbus, neither will be endangered. The quadrant of sclera usually selected is either the inferior temporal quadrant, lying between the external and the inferior rectus, or of the superior quadrant, lying between the internal and the superior rectus. The eyeball is rotated by fixation forceps applied to the globe near the limbus in the quadrant where the sclerotomy is being made. While the eye is steadied in this position, an assistant should grasp the conjunctiva and move it laterally from the site of the sclerotomy. A von Graefe cataract knife is passed through the conjunctiva, toward the center of the globe, with its cutting edge forward, penetrating for a distance of 2 to 3 mm. The incision is lengthened for a distance of 4 to 6 mm. by a careful sawing movement. Before the knife is withdrawn, it is turned upon its axis, at right angles to the original direction of its cut, and then immediately withdrawn. This separates the edges of the cut, permits a bead of vitreous to prolapse subconjunctivally, and changes the incision into an L shape. When the conjunctiva is released it moves backward so that conjunctival and scleral incisions do not overlie. The eye should be dressed for eight to twelve hours and then local applications and medication started as indicated.

The vitreous fistula which forms is rather likely to heal rapidly For this reason, several men have modified the incision to some extent. Some have changed it to a V- or U-shaped incision, with its two arms quite dissimilar in length, as in Parinaud's incision; others have recommended a crucial incision; others a T-shaped incision; and several others double scleral incision, passing the Graefe knife tangentially to the curve of the sclera as puncture and counterpuncture. A more permanent fistula can be made in a similar area with a 2-mm. trephining blade. A conjunctival flap is cut and the sclera trephined very carefully. The choroid should not be opened by the trephining blade. The disk is cut out cleanly, with sharp scissors, and the choroid then punctured with the straight cautery tip of a Ziegler cautery outfit. The underlying retina must be perforated at the same time to permit a bead of vitreous to prolapse. The operation is completed by a careful closure of the conjunctival flap. This should have been cut of such a size that the suture line is well away from the trephining opening through the sclera. The position for the vitreous fistula as a part of retinal separation surgery depends naturally and wholly upon the site of maximum retinal separation. In such instances, the purpose of the operation is to permit a freer release for subretinal fluids and not for the subconjunctival prolapse of the vitreous. The displacement of the vitreous by the separated retina ordinarily will prevent this.

Posterior Sclerotomy for the Removal of Foreign Bodies in the Vitreous Chamber.—In general, magnetic foreign bodies which lie in the vitreous and which are relatively fresh should be removed, if possible, through a

corneo-scleral incision. Non-magnetic metallic foreign bodies, other foreign bodies as a cysticercus, and even magnetic foreign bodies which have become encapsulated, must be removed through the posterior route. A discussion of the surgery of these conditions appears in Chapter XXVI.

SCLERAL SURGERY FOR HIGH MYOPIA

Lindner has recently considered the shortening of the sclera in high myopia, especially when this is combined with retinal separation. His recommendation consisted of the incision of the sclera and the resection and removal of the crescentic strip of sclera, with subsequent suturing of the scleral wound. The operation as he discussed it was to be done in two to four stages. A rectus muscle is detached from the sclera and a blunt crescent outlined upon the sclera with sharp but very careful incisions. A suture is passed through the apex of this crescent, the apex lifted from the underlying choroid, and with this suture as a tractor, the strip of sclera may be dissected free and lifted without damaging the choroid itself. The edges of the wound in the sclera should be closed with plain 6-0 catgut, the muscle reattached and the conjunctiva closed. Eight to ten days later the same procedure may be carried out upon the sclera under the belly of the opposite rectus muscle. The third stage under a third of the recti muscles, and the fourth stage carried out at the same interval upon the sclera under the rectus muscle antagonistic to that lifted for the third stage.

If the operation is at all feasible and practical the results should be due to the resection of a belt of sclera about the entire circumference of the eyeball. To achieve this it is manifestly necessary that the strip of sclera removed be accurately gauged in each instance. Further, that the tapering ends of each strip overlap each other so that the total width of the belt removed will be the same throughout. Further, the choroid must not be damaged. Lindner, in discussing the operation, stated that the surgery of myopia, if at all possible, must be based upon some procedure which achieves shortening of the sclera similar to this. It certainly seems to be applicable in cases of high myopia accompanied by retinal separation.

Borley[1] has recently discussed this surgery in detail. His procedure was outlined not so much for the treatment of high myopia as such, but for the correction of retinal separation when accompanied by or caused by high myopia (See Section under Retinal Separation.) The illustrations of Figure 500 Chapter XXV, A, B, and C, are the demonstrations of his technique. Attention is called especially, in this procedure of his, to the insertion of the scleral mattress sutures prior to the scleral resection. The insertion of these mattress sutures after the resection would be rather difficult. Hence, it is quite logical that they be introduced immediately after the section for removal is outlined, but before it is removed.

THE CORNEA

NON-PERFORATING FOREIGN BODIES OF THE CORNEA

The removal of these ordinarily is not an operating room procedure. The major portion of them can be removed quite properly in the ophthalmolo-

[1] Arch. Ophth., vol. 23, No. 6, June, 1940.

gist's office. Occasionally cases present themselves which should be hospitalized, as the foreign bodies are of a size or shape, or so implanted that their removal may result in the collapse of the anterior chamber.

Foreign bodies on the cornea consisting of coal, cinders, street dirt and grit, sand, portions of an insect and superficially implanted bits of glass need, ordinarily, only the instillation of a few drops of pontocain and their removal with a moistened cotton wound applicator. Occasionally the foreign bodies may be so small, of such a neutral color, or of such a minute particle of glass, that removal is best done with the patient seated at the slit lamp. After anesthetization, a light blepharostat should be introduced, and the foreign body removed with the applicator under direct slip lamp observation. Some of these may be more deeply buried so that a loop, a spud, or even the tip of a cataract knife is necessary to dislodge them. The postoperative treatment is that of preventing infection or of combating it if it has already become established. Under ordinary circumstances an aqueous solution of one of the mercury dyes is usually sufficient. Foreign bodies of stone, as with monument workers, or from grinding wheels, have been responsible for an unusually large number of late ulcerated cases, far more than is reasonable. In general, the treatment of a foreign body ulcerative keratitis is that of chemical cauterization and subsequent neutralization, atropinization, and the use of foreign proteids. Foreign bodies which became implanted while hot or which by their presence damage the cornea through tissue destruction, must be removed and the site of the foreign body curetted. A very fine corneal curet may be used, but even better is the curettage possible from twirling a fine dental burr between the thumb and index finger. Cross has a chock for this purpose, but it is not essential. The surgeon should be careful not to perforate the cornea. Metallic foreign bodies which have been buried in the cornea for more than a day oftentimes have a fine deposit of rust at their site. This also should be removed. Minute particles of glass may become buried in the cornea and the cornea epithelialize over them so that they will not be revealed by fluorescein. They will show up readily under the slip lamp.

Indolent ulcers of the cornea, especially those connected with an anesthetic cornea, and the ulcers from keratitis e lagophthalmo, need conjunctival protection, and it is wise to carry this procedure out as soon as possible. The surgery of conjunctival flaps has been discussed, as applicable to this. These same ulcers will oftentimes respond nicely to a permanent tarsorrhaphy as discussed under surgery of the lids. A van Lint may be first done, but if the ulcer remains unhealed after the recession of the flap, a tarsorrhaphy should correct the case satisfactorily. Marginal serpiginous ulcers (that is, Mooren's ulcer) are rather common surgical procedures. The serpiginous ulcer is undoubtedly from a pneumococcus infection. The etiology, however, of Mooren's marginal rodent corneal ulcer is not as clear. Browning[1] mentioned the various causes which have been suggested: as (*a*) neurotrophic; (*b*) from a specific bacillus; (*c*) nonspecific bacterial infections acting on a cornea vulnerable from metastatic disorders; and (*d*) tuberculosis. The anterior chamber with serpiginous ulcer, when accompanied by hypopyon, should be drained. There is no doubt that the Graefe-Saemisch incision stops the pain and frequently

[1] Berens, Disease of the Eye, W. B. Saunders Company, p. 507, 1936.

starts the patient on the road toward recovery in many cases. In doing this, a narrow cataract knife is introduced at the limbus, cutting edge forward passed across the anterior chamber to a counterpuncture at the limbus; there the edge of the knife should lie under the major portion of the ulcer. As soon as the counterpuncture has been done and the point of the knife emerges, the heel of the knife should be elevated fairly quickly, so that the edge cuts forward and upward as the knife is carried forward and upward directly through the cornea and through the middle of the ulcer in a clean horizontal cut. Irrigation of the anterior chamber may be done immediately of the débris, hypopyon, hæmorrhage, and fibrin, if drainage seems inadequate. Spontaneous perforation may occasionally occur in these cases, resulting often in a satisfactory outcome. Unfortunately, however, in some of these instances iris prolapse will also occur. Spontaneous extrusions of the lens also occur during this process of spontaneous perforation. In such instances the eyeball is unfortunately lost. Occasionally chemical or even actual thermic cauterization, and the use of foreign proteids, may improve these cases to such a marked degree that a conjunctival flap is indicated. Unipolar electro-desiccation is repeatedly valuable, this applied to the edges of the ulcer. There is no use, however, of transferring a flap across the surface of an ulcer in the presence of a pneumococcic infection. This must be first cleared up. Optochin should always be used. The medical treatment of a serpiginous ulcer must include atropinization, supportative treatment, and the use of foreign proteids. Subconjunctival injections of Pregl's iodine solution and of a 1 to 5000 aqueous solution of cyanid of mercury have often been of assistance. E. Fuchs repeatedly recommended the use of cod-liver oil internally, however. Mooren's ulcer is fortunately rather rare. Medical treatment seems to be of little avail. The author has found repeated corneal paracentesis through a normal portion of the cornea, combined with cauterization, to be of assistance. Repeated irrigations of the lacrimal sac, even in the absence of any manifest suppuration, should always be done. Deliminating keratomy has been tried with little success. Roentgen-ray therapy has been of assistance in some cases. Radium therapy has given some very satisfactory results as reported by Warden Smith.[1]

Dendritic ulcers from herpes of the cornea may become so extensive that they also assume surgical proportions. Roentgen-ray therapy is frequently valuable. Cauterization must be carried out if a hypopyon develops. Repeated paracentesis has been of assistance. Trichloracetic acid chemical cauterization is often of great value.

Early keratocele is by no means a hopeless condition, differing in this way quite decidedly from a late or older keratocele and keratectasia. Early extensive keratocele usually follows a burn of some type in the central region of the cornea, or is a bulging and herniation of Descemet's membrane after sloughing of the other portions of the cornea has occurred, as a result of extensive ulceration. Many of these cases are accompanied by a marked increase in the intra-ocular tension. Some of these cases respond very nicely to a single corneal paracentesis followed immediately by intermarginal lid adhesions arranged as a permanent tarsorrhaphy. Others, more extensive in elevation as well as in cross surface of the cornea involved,

[1] Recent Advances in Radium, London, J. and A. Churchill, 1935

have been treated by the author quite satisfactorily with a thick button of fascia lata held into the corneal defect by a bridged conjunctival flap in conjunction with temporary intermarginal adhesions, and a pressure bandage applied and not disturbed for eight days. At the end of this time the conjunctival sutures may be removed, the superfluous fascia lata removed, and the temporary intermarginal sutures replaced by permanent intermarginal adhesions. The herniation of Descemet's membrane disappears and there is a very definite filling in of the corneal tissue defect by cicatrix and corneal stroma. Naturally a dense central leukoma remains, but the eyes become quiet. These cases may need a peripheral optical iridectomy later, but even in these the permanent results are good. Emmons[1] reported one instance wherein he used a button of fascia lata over the corneal defect, and held this in place by two strips of fascia lata 9 mm. by 22 mm., fixed in the horizontal axis to the recti. His patient recovered with a 3-mm. leukoma in the center of the cornea without bulging, and with 20/70 vision. Mucous membrane grafts can be used in the same manner, but they will not be successful in suppuration, that is, if active corneal ulceration is still present. The fascia lata tampon seems to function even in the presence of such conditions.

Wright[2] treated a case of corneal ulcer with descemetocele and fistula by using a graft from the cornea of a blind glaucomatous eye. The reparative procedure was wholly successful.

In ulcer processes with a beginning descemetocele, a pressure bandage is one of the most important factors. As A. Fuchs[3] states, relative to these:

> If the attending surgeon has neglected by the application of a pressure bandage and the prescribing of rest in bed to press back the membrane and promote normal scar formation, the advancing descemetocele will become fixed by a whitish ring of scar tissue, in which it will appear as a slightly protruding black vesicle. Then a pressure bandage will no longer aid, because the membrane is already firmly adherent to the walls of the perforation. Only cauterization will help which must include about half of the thickness of the cornea and descemetocele. There will be no anterior chamber afterward, but the iris does not generally wedge itself in, as the canal is small and its margins are very smooth, being lined by Descemet's membrane. One should dust bismuth tribromphenate on the cauterized area in order to bring about as rapid a closure as possible and restoration of the anterior chamber. A tight-fitting bandage is applied, and the patient is ordered to lie quietly in bed for a few days. After a few days scar formation begins, which is now no longer hindered by the protruding descemetocele, and a normal closure of the canal is brought about.

A. Fuchs[3] is very much in favor of trephining the cornea for serpiginous ulcer of the cornea. His explanation is as follows:

> In many cases of ulcus serpens there is an infiltration of the anterior surface of Descemet's membrane by leukocytes. Such an infiltration may develop into a "posterior abscess." Naturally Descemet's membrane in this region is separated by the pus from the stroma of the cornea. If the trephine now penetrates the cornea, the sharp edge pressed back the more resistant Descemet's membrane without penetrating it and thus produces detachment of the membrane. It is then advisable not to advance the trephine farther but to take a sharp needle (for example, a discission needle or a Graefe knife) and perforate Descemet's membrane obliquely through the trephine opening. This can be accomplished because the membrane is easier to penetrate obliquely; then, too, this obviates the danger of injuring the lens. Of course, the aqueous does not gush out as fast as it would if a

[1] Am. Jour. Ophth., October, 1931.
[2] Brit. Jour. Ophth., 19, 341, June, 1935.
[3] Arch. Ophth., vol. 16, September, 1936.

1 mm. perforation with the trephine had been made. Nor is the hypopyon immediately washed out; but after twenty-four hours, when the bandaged are again changed, one will usually find the chamber abolished and the hypopyon removed. The lips of Descemet's membrane evidently roll forward into the trephine opening of the cornea and prevent a closure of the opening although it is very small. A knowledge of these conditions is important for the treatment of ulcus serpens by the Sonderman trephining and will prevent bad results.

Happenings similar to these may occur in connection with the Elliot trephining, namely, when the trephining is done too near the cornea or when Descemet's membrane extends rather peripherally than usual. Under these circumstances the operator has the impression that the trephine has penetrated the cornea, but he seeks in vain for the appearance of any protruding vesicle of iris. The scleral flap is removed, and he sees a dark background through the trephine opening, but it is impossible to advance the trephine so far that the iris protrudes. This impossibility, to be sure, concerns only the cautious operator, for the careless operator will bear down hard and thus force the trephine to penetrate the protruding Descemet's membrane, and at the same time it will go through the iris and injure the lens.

Traumatisms of the cornea when caused by thermic or chemical agents may result in extensive damage. The late results from these and the correction of these conditions have been considered under the discussion of symblepharon and cul-de-sac reformations. Practically, alkali burns are much more severe than are those from an acid. Sloughing is more extensive and healing occurs very slowly. A burn from commercial lime is far worse in its results than that of sulphuric acid or even nitric acid. Recent lime injuries should be quieted by cocain in oil or by holocain, and the lime neutralized with thorough lavage by 2 per cent aqueous solution of ammonium chloride or a 5 to 6 per cent solution of neutral ammonium tartrate. Lid elevators may be necessary to achieve adequate flushing of the conjunctival cul-de-sacs. Early conjunctival plastics are permitted in many of these instances, especially in those cases wherein a large portion of the superficial cornea has been destroyed. Extensive destruction of the complete surface of the cornea is almost fatal to the integrity of the eyeball and to vision.

Traumatisms of the cornea which demand surgical procedures are seldom simple procedures. The lens is often damaged, an iris prolapse is certain to be a complication, and the resulting corneal cicatrices and anterior leukomata are distressing results. Metallic foreign bodies may become buried in the cornea so that the cornea has been perforated. Copper scales, copper wire, coal, glass and hot solder have all been seen implanted in this manner. Such foreign bodies, when magnetic, are readily removed thereby. Forceps extraction is necessary otherwise. In most instances, a corneal injury accompanied by an iris prolapse must usually be corrected by an iridectomy and a subsequent conjunctival flap. If the injury is limbal in extent, the iridectomy may be done directly through the limbal perforation. If it is more nearly central, however, a fresh keratome incision should be done at the limbus, near to the perforation, and the iris withdrawn from the perforation through that incision. In some of these cases, especially when the injury is freshly sustained, it is possible to release the iris from the perforation, and smooth it flat with an iris spatula. A peripheral iridotomy should, however, be done immediately to permit the early formation of a layer of aqueous between the surface of the iris and Descemet's membrane to prevent the development of leukoma adherens. In

general, these cases of perforation of the cornea with an iris prolapse are best handled by an iridectomy of the prolapsed portion of the iris.

The repair of simple non-complicated perforating injuries of the cornea is usually a simple matter. Many authors have recommended a direct suturing of the cornea with fine silk. This hardly seems necessary. If there has been no iris prolapse or there is no iris incarceration, further danger of this disappears as soon as the anterior chamber has reformed. A conjunctival flap, as has been outlined, is usually sufficient to seal the anterior chamber and to permit its refilling. Koyle's keratoplasty, a modification of the de Wecker and the Kuhnt, is ideal for these cases. Two tongue flaps are dissected free from the bulbar conjunctiva, one on each side of the corneal defect which is to be closed, as in A of Figure 401. A third incision is made beneath these two flaps parallel to them and at some

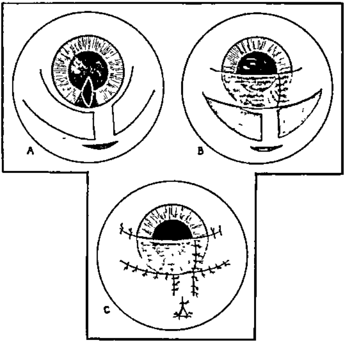

FIG 401.—Koyle's keratoplasty.

distance from them to permit their approximation. The two pedicle flaps are brought up and sutured together. They should be arranged, however, of unequal length so that their suture line is offset from the site of the corneal defect. The advantage of these two flaps lies in the tension which they exert upon the underlying cornea furnishing thereby approximation for healing. The flaps are especially satisfactory following extensive perforating wounds of the cornea close to the limbus, and in resections of the cornea for various indications. Took[1] is correct in stating that an iris prolapse is Nature's attempt to avoid infection. Würdemann[2] states that this structure becomes pinched and sooner or later causes iridocyclitis and sympathetic ophthalmitis. Corneal lacerations are usually sharply out-

[1] Ophth Record, August, 1908.
[2] Injuries of the Eye, 2d ed., C. V. Mosby Company, 1932.

lined, and if treated surgically at this time, a minimal amount of scarring results. Twenty-four to forty-eight hours after the accident, however, the lips of the wound become swollen, the edges are rounded, striped keratitis appears, and the lips usually gape. In examining cases for a possible perforating injury of the cornea, it is not sufficient to permit finger tension to decide the presence of a perforation. Minute punctures from needles, etc., can only be observed with the slit lamp. These types of injuries oftentimes go on to the formation of a traumatic cataract and an adherent leukoma is just as common with a small wound as it is with a larger one. The determination of the presence of a foreign body, in all corneal wounds, is a most important part of the examination.

Foreign bodies in the anterior chamber may be simple problems surgically; they can also in some instances be quite difficult. The pupil should be contracted immediately after they have been discovered, to prevent them from passing through the pupillary aperture into the posterior chamber of the eye. The author had a case with a piece of coal in the vitreous chamber, with aphakia, wherein by postural changes the coal was jolted into the anterior chamber, the pupil closed with eserin, and the subsequent extraction of the foreign body was most uneventful.

A keratome incision should be made at the limbus through the cornea proper as close to the foreign body as it is possible to get without touching the body itself. Iris forceps, a small hook, an iris spatula or a small lens loop may all be used, as occasion demands, to remove the foreign body from the anterior chamber. Minute foreign bodies which become lodged in the angle may need an extension of the incision into the angle with sharp scissors before these can be removed. Naturally, one must be careful not to traumatize the lens and, further, not to permit small metallic foreign bodies to become entangled in the meshes of the iris stroma. In such instances it may be necessary to do an iridectomy to remove the entangled foreign body. Non-magnetic metallic foreign bodies may be difficult to remove because of this complication. Magnetic foreign bodies may be released from the iris stroma by applying the magnet to the cornea above the foreign body, lifting it and coaxing it along the posterior surface of the cornea to the position where a keratome incision is to be made. All cases of foreign bodies in the anterior chamber should be considered infected and are to be treated universally with atropinization and with foreign proteid therapy. A leukoma adherens is not always of surgical importance. If irritation continues, however, of if iris stroma of any great degree is incarcerated, the case then should be corrected surgically (see Iris Surgery). The Wheeler knife needle, with careful illumination and with magnification by a loupe, is necessary. In some instances the finer and more delicate Ziegler knife needle is sufficient. The knife needle is passed through the cornea at the limbus, at a point near the adherent leukoma, so that this point of entrance will be the fulcrum from which the needle cuts. The tip of the knife needle is then manipulated so that the adhesion may be freed from the posterior surface of the cornea, as close to the cornea as is possible, without incising the cornea; otherwise adherent tags of iris will remain on the cornea. In some instances the blunt back of the knife can be used to tear fibrous adhesions from the cornea. Large, broad, iritic adhesions will need the Wheeler knife needle for satisfactory sectioning. Iris stroma, if incarcerated anteriorly in the parenchyma of the cornea below the level of

Bowman's membrane, cannot be removed. If, however, it lies or rests above the level of Bowman's membrane, then one should break through the corneal epithelium with a curet and scrape this prolapsed and incarcerated iris tissue away from the surface of the cornea. Light cauterization with a straight Ziegler cautery tip is quite satisfactory, though it must be used rather carefully.

Occasionally, a leukoma adherens is so dense that a Graefe cataract knife is necessary. This is especially true with adherent leukomata nearer to the limbus than to the center of the cornea. In these cases a thin cataract knife is passed, with puncture and counterpuncture, from limbus to limbus, and with its cutting edge toward the adherent iris. The cutting edge of the knife can be carried toward and across the adherent iris with careful to-and-fro sawing movements, severing the anterior synechiæ. If it is necessary to carry the knife out to a complete corneal scleral incision, as would be done for a Lagrange type of sclerectomy, then naturally it must be so completed. If all adhesions, however, have been cut before this stage is reached, the knife may be withdrawn as soon as is proper. The operator should be careful not to lose the anterior chamber if it is at all possible to save it, and to be particularly careful not to damage the lens. Even with the best of care, this complication occurs at times.

CORNEAL PARACENTESIS (Paracentesis of the Anterior Chamber)

Paracentesis of the cornea is a sound and valuable surgical procedure. Its indications are rather extensive and include, in part, the following surgical and medical conditions: (1) In the treatment of acute iritic or secondary glaucoma, to reduce the tension temporarily and to permit better absorption of the medications used to dilate the pupil and to release the synechiæ. (2) For the temporary relief of hypertension in acute hæmorrhage glaucoma. (3) Occasionally, to relieve the tension, temporarily, in acute congestive glaucoma wherein more extensive surgery cannot be done at that time, and wherein the response from miotics (as well as from the other forms of therapy for the glaucoma) is not satisfactory. (4) For drainage of the anterior chamber in corneal ulcerations and for grave forms of acute plastic iritis when accompanied by acute secondary glaucoma. The presence of a hypopyon is not always, of itself, an indication for either paracentesis or for a Graefe-Saemisch incision. (5) In the treatment of chronic uveitis as recommended by Brown. In this, as soon as a satisfactory typhoid antibody titer has appeared in the blood serum, repeated paracenteses of the anterior chamber through the cornea are a valuable therapeutic adjunct. (6) Paracentesis has been recommended in high degrees of keratoconus, especially with grave thinning of the cornea at the apex of the cone. (7) For drainage of a severe and complete hyphemia in non-perforating impact injuries to the globe. These are not only indicated therapeutically but also are occasionally necessary to permit a satisfactory examination and to determine the extent of the damage which has resulted from the injury. (8) To permit relief of tension from sudden and extensive swelling of the lens after traumatisms to the eye. (9) Repeated paracentesis is of value in cases of marked vitreous opacities. (10) Keratitis bullosa seems to be improved, not uncommonly, as a result of its use. (11) Occasionally with intensely acute iritis and iridocyclitis even without secondary

hypertension, paracentesis results in a marked decrease in the pain and seems to permit a better absorption of the medication. Also, perhaps permits greater response to the other adjunct treatments being used.

Paracentesis in helping to clear up vitreous opacities and uveal inflammation with normal tension is probably based on an effect produced by tissue metamorphosis, but just how this comes about is not clear.[1] Certainly, the reason for the satisfactory results, which the author has had, in bullous keratitis with repeated paracenteses are even less clear. It seems difficult to believe that the transient lowering of the ocular tension was the sole reason for the improvement and the cure which resulted. On the other hand, keratectasia, as it is seen following iridocyclitis, corneal ulcers, and even interstitial keratitis, can be combated quite satisfactorily by repeated corneal paracentesis and with a pressure bandage. These instances do have an increase in the ocular tension and the beneficial results may be ascribed to the lowering of this hypertension and the subsequent support given to the tissues by the pressure bandage which must be used at the same time.

The operation, because of its simplicity, can be repeated frequently for its effects are but temporary. In some instances the reformation of the secondary aqueous (which has a different colloid and salt content) is the therapeutic effect desired. There is no doubt that a paracentesis has repeatedly been the means of saving an eyeball endangered by severe corneal ulceration. The operation can be done under local anesthesia, though in the presence of very painful eyes and with very nervous individuals it may be necessary to use gas and oxygen, or even venethene. If proper asepsis is carried out, the procedure need not be done in the operating room, but may be performed in the patient's bed in her room or in the ward. Usually the point of entrance should be just within the limbus, but the site of incision depends upon several other circumstances. Drainage for a hyphemia should be at 6 o'clock on the limbus. In other instances the upper half of the corneal circumference is more easily utilized. A blepharostat may be necessary with some cases, but it should not be used if there is any possibility of the patient squeezing or if the tension of the eye is unduly high. In such instances an assistant must hold the lids apart with lid hooks or with some type of lid retractor. A small angular keratome is satisfactory, though if blood or pus is to be evacuated or lens masses to be washed out, a von Graefe knife had better be chosen. The eyeball is grasped with a fixation forceps, at a point opposite to the position for the paracentesis. The point of the keratome is applied to the cornea with the blade perpendicular to the cornea. As soon as the anterior chamber has been entered, the handle should be depressed so that the plane of the blade is now parallel to the plane of the iris. The point is advanced for 1 mm. or more, depending upon the size of the incision which is desired. The keratome is withdrawn slowly with the point directed slightly upward by further depressing the handle, at the same time moving it to the side so the aqueous will not gush out suddenly. Figure 402, *A*, shows the direction of the blade for entrance into the anterior chamber and the subsequent position for making the incision; *B* is a front view of the incision completed; and *C* illustrates the manner in which the keratome should be withdrawn to

[1] Hardy, The Rôle of Paracentesis in Ophthalmology, Am. Jour. Ophth., Ser. 3, vol. 19, December, 1936.

prevent too sudden emptying of the anterior chamber and possible damage thereby to the lens. After the keratome has been withdrawn, if the drainage is not immediately satisfactory, one lip of the wound may be depressed with an iris spatula, causing the incision to gape and permitting further drainage. In general, no complications should be connected with the operation. When a cataract knife is used, the corneal puncture and counterpuncture are both made with the edge directed toward the limbus, the incision, as in *D*, of Figure 402. When the knife is withdrawn, the incision may be extended as is necessary. Following the operation, the cul-de-sac should be cleansed and a dressing applied for eight to twelve hours thereafter. It can be removed temporarily for any medication or for sterile hot compresses if these are indicated. Twenty-four hours after a paracentesis, the original incision may be again reopened, with an iris spatula, and the

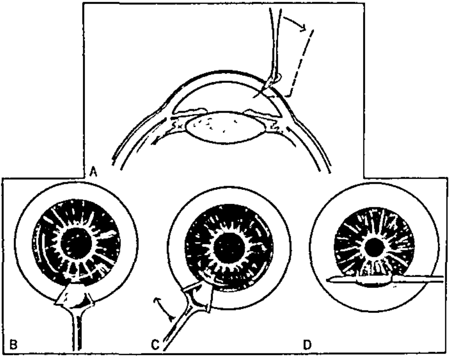

Fig. 402 —Corneal paracentesis *A*, *B* and *C*, with keratome, *D*, with cataract knife

anterior chamber again completely drained. A different site should be selected for any necessary subsequent paracenteses. The circumference at the limbus is adequate for as many as indicated.

Another procedure of minor surgical technique but of major importance is that of cauterization of the cornea, either with a thermophore, with a pasteurizer, or with the actual cautery. Each has separate indications. The thermophore and pasteurization of the cornea are especially valuable in indolent ulcers, infected though stationary, in abrasions, and in recent slow healing wounds. They are of great assistance in clearing up the lesser degrees of pannus, and pasteurization especially is of definite value in assisting in the absorption of recent superficial scarring. The thermophore and pasteurization are both indicated in the milder kerato-conjunctival eczematous forms of ulcer.

The thermophore is a patented instrument permitting application of graded heat directly to the cornea, having many different shaped points for topical application of the graded heat. A pasteurizer is some form of olive- or egg-shaped solid copper head which can be heated to a cherry heat, in an alcohol lamp, and then to be held either apex or base, as close to the area of the involvement as it is possible to hold it without touching the tissue.

Cauterization is indicated in conditions similar though more severe in degree; as in extensive ulcerations of the cornea, when indolent and especially when infected; after pterygium operations when there seems to be an early recurrence or when tags of pterygium tissue have remained adherent to the cornea; and in old fistulæ. This same applies to cystic scars, to keratocele, and perhaps to the very small ectasia rather rarely seen. Injuries of the cornea and lacerations of the cornea with an iris prolapse or an iris incarceration with the lips of the wound, can be cleaned up nicely with careful cauterization. An anterior chamber must be present and the cautery should be lightly though adequately applied. Following the use of cautery it is permissible to introduce an iris spatula into the anterior chamber and free the iris to prevent subsequent adhesions. Keratoconus has been treated by cauterization as well.

For corneal cauterization one should use the fine straight point of the classical Ziegler cautery outfit with sufficient heat in the tip so that tissues will not adhere to the cautery point, but more than this is unnecessary and dangerous. A light cherry-red glow is perhaps the proper designation for the correct amount of heat.

The same thing applies to the surgical treatment of tumors of the cornea, as dermoids and epitheliomata. Superficial cauterization of these will oftentimes result in a complete cure.

CORNEAL TATTOOING

Corneal tattooing is a surgical procedure indicated in conspicuous corneal leukomata It is especially valuable in complete irido-dialysis, in aniridia, and in albinism, to form an opaque limbal diaphragm. It should not be used in the presence of adherent leukomata nor with degenerated eyeballs, because an irido-cyclitis or even a possible sympathetic inflammation in the other eye may be activated. A. A. Knapp feels that an optical iridectomy when combined with corneal tattooing[1] in a central corneal opacity which occludes the entire pupillary area, is as productive of a good visual acuity as a corneal graft. Also, the procedure is far less hazardous than a corneal transplant. He states:

> A number of these operations has been done and has been found very successful. Routinely, the tattooing is done first, using platinum or gold, reducing with hydrazine hydrate for the central black pupil. In a few cases, the opacities have been so extensive as to encroach on the iris area of the cornea; for these patients I have tattooed two colors at the same time, the black and brown, with a good take. After the eye has been quiet for about three weeks, an optical iridectomy is performed. Three patients who had central corneal opacities, and who had had optical iridectomies performed prior to being seen, had their leukomas tattooed, and all three of them showed improved vision, both subjectively and objectively.

There are three satisfactory procedures for this: India ink, gold chloride, and platinum chloride.

[1] Personal communication.

Tattooing With India Ink.—A good quality of India ink should be used. The type which is purchased in a cake is especially satisfactory. A certain amount indicated should be scraped from the cake, placed in a paper envelope and sterilized in an autoclave. This envelope is brought to the operating table unopened; there it is to be mixed in a 1 to 1000 aqueous solution of bichloride of mercury until a thick black paste has been formed. Cocain instillation anesthesia is sufficient. There are several ways of applying the India ink. The many-toothed tattooing needle is not especially satisfactory. The corneal epithelium is extensively lacerated by this, but sufficient of the epithelium remains to prevent a satisfactory tattooing. Oftentimes when the needle is used the process must be repeated several times. The area to be tattooed should be superficially outlined with a scalpel and then the corneal epithelium and the superficial corneal lamellæ stripped away within this incision. The India ink is placed on the denuded area and massaged into the layers of the cornea with an iris spatula. Frequent irrigations with boric acid will make it possible to determine when the entire area has been properly covered. Czermak uses a trephine and a keratome to strip off the epithelium and then tattoos with a needle. Dimmer dissected up the superficial layers of the cornea with a keratome but allowed it to remain hinged at one end for subsequent healing at its original position. This is not always satisfactory in these dense white leukomata which are the best indication for tattooing. After the operation, the iris should be quieted with atropine and a dressing worn until epithelialization has recurred. It may be necessary to repeat the operation after several weeks. Further, the tattooed area may fade and become gray after several years.

Tattooing With Gold Chloride.—Knapp (Basel)[1] first presented a method of chemical tattooing of the cornea by the precipitation of gold chloride into the corneal stroma. Ellett[2] and Gifford and Steinberg[3] also discussed the same subject. Pischel[4] covered the whole subject of chemical tattooing in detail. He reported best results as being obtained from the use of a 2 per cent gold chloride solution, neutralized with sodium bicarbonate until it is just faintly acid to litmus paper. Pischel said, "A too strongly acid solution undue irritation and vascularization which is undesirable. The gold chloride does not need to be sterilized, as it is an antiseptic itself. Very dense and vascular leukomas may need a 3 per cent or possibly a 5 per cent solution." The exact technique as outlined by Pischel in his original article is as follows:

(1) The cornea is anesthetized with cocain or phenacaine, without epinephrine (2) The area to be stained is outlined carefully with a large trephine or fine knife The epithelium is thoroughly and evenly scraped off. (3) Hæmorrhage is stopped without the use of epinephrine. (4) A cotton carrier, large enough to cover the part to be stained, is dipped in the faintly acid gold chloride 2 per cent solution, pressed out so as not be dripping wet, and held against the denuded area. A fresh applicator is used every minute. After three minutes there will be a brown and after five minutes an almost black stain. (5) The reducing agent, epinephrine, or the more vigorous fresh 2 per cent tannic acid, is then dropped on the surface of the cornea for from one to two minutes; the eye is flushed with physiologic solution of sodium chloride, and is then bandaged.

[1] Klin Monatsbl f. Augenh., 77, 289, 1926.
[2] Am Jour. Ophth, 9, 771, 1926
[3] Am Jour Ophth, 10, 240, April, 1927
[4] Arch. Ophth, 3, 176, February, 1930.

Adrenalin will reduce gold chloride as soon as it is applied, and before it can penetrate into the corneal stroma; therefore, adrenalin must not be used during the corneal surgery. Further, additional gold chloride cannot be used after the adrenalin has been applied. Pischel also called attention to the fact that tattooing has been tried twice in albinos and in both instances severe reactions developed with a slough of the superficial layers of the cornea.

Tattooing With Platinum Chloride.—The technique is similar to that of the gold chloride, but it is simpler in that no neutralization of the platinum solution is necessary. The hydrazine hydrate solution used should be a freshly made 2 per cent aqueous solution, not more than a week to ten days old Pischel's outline for this treatment is as follows:

(1) The field is prepared (anesthetizing and scraping of the epithelium) as for gold chloride (2) It is washed with sterile distilled water instead of salt solution. (3) Two per cent platinum chloride is then applied on an applicator as for the gold chloride, for two minutes (4) It is reduced with hydrazine hydrate for twenty-five seconds, then washed promptly with sterile water. The color should appear promptly by this time The hydrazine hydrate is best applied from a dropper, a small drop being allowed to run onto the treated area and rest there until washed off. This prevents any unnecessary irritation of the remainder of the cornea. (5) Two minutes later the eye is washed well with physiological solution of sodium chloride (6) The eye is then bandaged.

In general, gold and platinum result in a corneal stain which is more permanent than is that obtained from India ink, but the color of the stain is brown rather than black.

CORNEAL SCARS

The surgery of corneal scars is at the present time not especially satisfactory. The matter of corneal transplants will be discussed very shortly by a section written for publication here by Castroviejo. The surgical resection of dense superficial corneal scars has been successful, in part. Corneal vascularization, if present at the same time, will nullify the result. Penetrating scars also do not lend themselves to the excision of the superficial layers of the cornea. One case of bare motion perception was improved to the counting of fingers, and the operation is to be recommended only for defects as serious as this. If an optical iridectomy can be utilized, as an addition, this should be done. Cocain anesthesia is sufficient. A very shallow incision is to be made at the limbus, at 4 or 5 o'clock. With a fine iris spatula, the superficial layers of the cornea are lifted, at the limbus, at a level below Bowman's membrane. The point of a cataract knife or a keratome also can be used. As soon as the edge of this is freed so it can be grasped with fixation forceps, the corneal lamella loosened is stripped off and up toward the pupillar area. If the amount which is to be raised is also outlined by superficial corneal incisions connected with the limbal incision and carried across the region of the pupillary aperture, then the elevation and stripping of these lamellæ will be facilitated. Atropinization completes the operation, and a dressing is applied after the conjunctival cul-de-sac has been well filled with sterile white petrolatum. Good results have been reported in some instances with the removal of one-half of the corneal thickness. Apparently the corneal epithelium spreads over the region denuded and in this way prevents the redevelopment of a scar there. That

part of the cornea which is thinned out does not regenerate, however. The postoperative dressing should not be removed for forty-eight hours and preferably not for seventy-two hours. At that time it may be removed, the eye cleansed with warm boric acid, atropine again instilled and a second dressing applied for forty-eight hours more. The writer uses foreign proteid therapy routinely the day of the operation, with two subsequent injections being given thereafter. It is quite possible that further improvement may be obtained through a later optical iridectomy.

CORNEAL TRANSPLANTS OR KERATOPLASTY

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Keratoplasty, or corneal transplantation, is the operative replacement of damaged corneal tissue by healthy corneal tissue. The operation is indicated in cases of corneal opacities or corneal irregularities, such as keratoconus and keratectasias. According to Salzer, the term autotransplant should be applied when the donor of the tissue to be transplanted is the same individual, homotransplant when the tissue is obtained from individuals of the same species, and heterotransplant when it is obtained from individuals of different species.

With regard to the type of operation and the relation of the size of the transplant to the rest of the eye, the nomenclature of Ascher, which is as follows, seems to be the clearest: (*a*) Total keratoplasty, wherein the entire cornea is transplanted as a whole, with or without 2 or 3 mm. of surrounding conjunctiva; (*b*) circumscribed or partial lamellar keratoplasty, wherein a circumscribed area of superficial lamellæ of opaque cornea is replaced by similar tissue from a transparent cornea; and (*c*) circumscribed or partial penetrating keratoplasty, wherein a variable area of full thickness of the opaque cornea is replaced by a corresponding piece of transparent cornea.

Historical Review.—An exhaustive review of the literature would lengthen this presentation excessively. The limitation of space will allow mention of only the most significant contributions, with special reference to those containing original work. Those interested in more detailed description of technique and bibliography are referred to the papers by Wood up to 1914; by Walker to 1917; by Ascher and by Kuhnt to 1922; and by Foster to 1923. This present review will bring the literature on the subject up to date.

Mülbauer, in 1840, performed a few experiments of reparatory keratoplasty, dissecting flaps that afterwards were left in the same place. In further experiments, following the idea of Walther, he performed a few operations using heterotransplants, namely, corneas of animals for placement in the eyes of human beings. The flaps were in the form of equilateral triangles, two-thirds thickness of the cornea, leaving Descemet's membrane intact (Fig. 403).

Bigger, in 1837, also claims to have attained success in transplanting corneas from one animal to another of the same species. Encouraged by the report of Bigger, Kissam, in 1838, reported his results in transplanting the cornea of a six-months-old pig to a human, blinded by a central corneal opacity. The operation was of the penetrating type, the leukoma being removed by means of a Beer's knife. The transplant was fixed in place by

sutures. Vision improved immediately after the operation, but within fifteen days the transplant became completely opaque, and later absorbed. A similar experience was reported in 1844 by Wutzer, using the cornea of a living sheep transplanted to a human eye. The transplant took, but became completely opaque shortly after the operation.

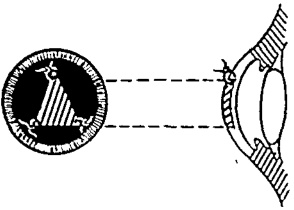

FIG. 403.—Mülhauer's method of circumscribed lamellar keratoplasty. (Castroviejo.)

The unsatisfactory results obtained up to this time in this type of operation were apparently the cause of the abandonment of further work on this subject until 1872. In this year Power performed a few experiments on reparatory keratotomy, in glaucomatous eyes. Penetrating flaps of cornea were made, and allowed to heal in the same place. Power reported that in the human cases union occurred by first intention and without irritation or suppuration, but when he tried to transplant in rabbits, cats and dogs, the flaps became opaque.

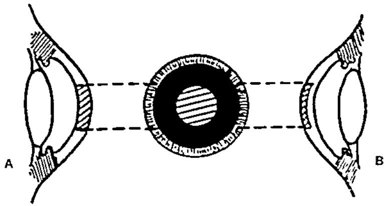

FIG. 404.—*A*, Von Hippel's technique of circumscribed penetrating keratoplasty; *B*, Von Hippel's method of circumscribed lamellar keratoplasty. (Castroviejo.)

Von Hippel, in 1877, described his technique of partial penetrating keratoplasty (Fig. 404), using a trephine for the purpose of obtaining transplants which would be of the same shape as the defect. The transplant was not sutured, but was kept in place by pressure of the eyelids only.

In 1877 Dürr conceived another method of partial superficial keratoplasty (Fig. 405, *B*), using corneas of rabbits for placement in human eye.

The flaps were taken from both cornea and conjunctiva. The corneal flap was triangular, 5 to 8 mm. long by 5 to 6 mm. broad, and was placed in the periphery of the cornea, and was kept in position by three sutures inserted in the three corners of the conjunctival flap. The epithelium opacified the second day to such an extent that the iris could not be seen through the transplant. A few days later the flaps vascularized, but some of them finally cleared.

Sellerbeck, in 1877, using the Von Hippel's trephine in operations on human subjects (homoplasty), and the penetrating type of operation, held the transplant in position with a flap dissected from the lower part of the bulbar conjunctiva, and sutured to the upper limbus. Sellerbeck recommended the use of corneas of asphyxiated fetuses and also advised puncture of the anterior chamber to avoid excessive pressure during the period of cicatrization. His experiments were not successful.

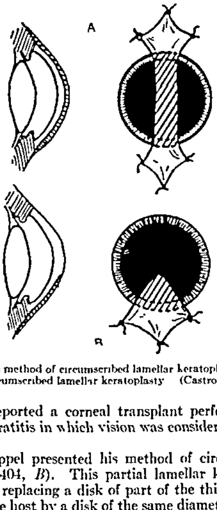

Fig. 405.—*A*, Löhlein's method of circumscribed lamellar keratoplasty. *B*, Durr's method of circumscribed lamellar keratoplasty (Castroviejo.)

Fuchs in 1888 reported a corneal transplant performed on a case of parenchymatous keratitis in which vision was considerably improved after operation.

In 1888 Von Hippel presented his method of circumscribed lamellar keratoplasty (Fig. 404, *B*). This partial lamellar keratoplasty of Von Hippel consisted in replacing a disk of part of the thickness of the leukomatous cornea of the host by a disk of the same diameter, but of full thickness, taken from the cornea of a dog. Von Hippel claimed that with his technique the problem of keratoplasty in relation to form and size of the transplant had been solved. He also stated that lamellar keratoplasty was easier to perform than the penetrating type, and was less liable to loss of

he implanted a disk of cornea taken from the other eye of the patient (autoplasty), which was blind. *The transplant was inserted as the crystal* of a watch is inserted (Fig. 407), leaving an oval area of 7 by 5 mm., through which the pupil could be easily seen. The transplant was dissected with Graefe's knife. There was vascularization at the end of a few weeks, which later cleared and the patient could count fingers at 4 or 5 meters. Five years later the transplant was still transparent.

In 1910, Löhlein presented another operation which he tried successfully on rabbits, and afterwards on human beings, obtaining in one case a vision of 6/60. Using parallel knives, he made two parallel incisions in the cornea 4 mm. apart (Fig. 405, *A*), extending from one limbus to the other. The corneas of patients with leukoma were dissected without penetrating into the anterior chamber, and at both ends of the transplant conjunctival flaps were made similar to those advocated by Dürr. Afterwards a transplant corneal band of the same shape and size as the one removed from the leukomatous eye, with two conjunctival flaps attached to it, was obtained from an enucleated eye of a living person or from a cadaver shortly after death. The transplant was placed in the eye of the host suturing the conjunctival

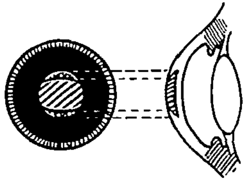

Fig. 407.—Plange's method of circumscribed lamellar keratoplasty (Castroviejo)

flaps. Healing took place with much reaction. Every transplant vascularized *in the first few weeks, clearing afterwards* Microscopic examination of successful transplants made in the eyes of rabbits one year after the operation, disclosed that Descemet's membrane and the posterior corneal lamellas were of normal structure, blood-vessels having developed in the place corresponding to the base of cicatrization. The lamellar disposition of the transplant was different from that in the cornea of the host. In the transplant, the lamellæ were wavy with increase in the number of nuclei and corneal corpuscles.

Kusnezow and Elschnig in 1913, Bruckner in 1914, and Beljaew in 1925, reported cases in which the operation was performed according to the technique of Löhlein, the transplants opacifying completely.

Morax, in 1912, presented a method of keratoplasty by transposition (Fig. 408); interchanging a transplant, obtained with a trephine on the periphery of the cornea of the eye, with a similar disk obtained in the opacified pupillary zone of the same eye.

Filatov in 1913 reported the first case of total keratoplasty. He transplanted the whole cornea together with a small margin of sclera and con-

vitreous and displacement of other intra-ocular structures, as well as of the lens. Von Hippel stated that at the end of the third week the transplant was completely healed to the surrounding tissue of the host, but at the base of cicatrization a nebulous infiltration was left, which never clarified completely, although it remained clearer than the removed leukoma. Von Hippel reported the case of a patient operated upon according to his technique, where vision increased one year after the operation from counting fingers at 2 meters to 20/200.

Wagenmann, in 1888, was the first to describe the operation of total keratoplasty, or the use of a whole corneal transplant, with a portion of the conjunctiva attached.

Both Fox and Smith reported cases in 1888 in which operation was performed after the partial penetrating technique of Von Hippel, with improvement of vision. Smith in 1890 reported the transplantation of a portion of a rabbit cornea into the eye of a human. The transplant retained a certain degree of transparency at the end of fifteen months.

In 1894, Fuchs reported 30 operations performed by the partial lamellar technique of Von Hippel, and saw improvement of vision in only 2 cases of parenchymatous keratitis.

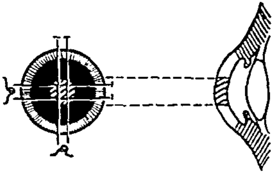

FIG. 406.—Zirm's technique to hold the transplant in position. (Castroviejo.)

Zirm in 1906 operated on one patient with leukomatous cornea as a result of a lime burn, using Von Hippel's trephine and Von Hippel's technique of partial penetrating keratoplasty. The flap was held in position with cross sutures inserted in the conjunctiva close to the limbus (Fig. 406). Vision after the operation was sufficient to distinguish motion of the hand. One year afterwards vision was 36/100. In his article, Zirm reached the following conclusions: the cornea of a young person only should be used as a substitute; Von Hippel's trephine should be used exclusively, and thus coaption of the margins of the transplant with the surrounding corneal tissue could be effected; if any anterior chamber exists, instillation of eserine should be resorted to; deep narcosis, strict asepsis and no antiseptics should be employed; the flap should be protected between pieces of gauze moistened with sterile physiological solution of sodium chloride, kept warm by steam; and only central scars of the cornea are suited for the performance of keratoplasty.

Plange in 1908 presented another case in which partial superficial keratoplasty was performed because the cornea had been burned with lime. After removal of the leukoma, leaving untouched the deeper layers of the cornea,

he implanted a disk of cornea taken from the other eye of the patient (autoplasty), which was blind. The transplant was inserted as the crystal of a watch is inserted (Fig. 407), leaving an oval area of 7 by 5 mm., through which the pupil could be easily seen. The transplant was dissected with Graefe's knife. There was vascularization at the end of a few weeks, which later cleared and the patient could count fingers at 4 or 5 meters. Five years later the transplant was still transparent.

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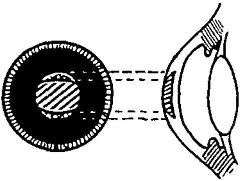

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junctiva. In the same year Schimanowsky reported 2 cases in which the whole anterior segment of the eye was transplanted (homoplasty), except the lens; that is, the conjunctiva, cornea, and sclera to the equator, ciliary body and iris were transplanted. In the first eye operated on, the vision obtained was sufficient to distinguish fingers at 0.5 meter seven months after the operation; afterwards vision gradually failed. In another eye the cornea was clear for ninety-eight days after operation; then the eye degenerated (phthisis bulbi).

Leoz Ortin in 1914, 1916, and 1931 performed experiments that were particularly interesting in the study of nerve regeneration of the transplants. The first four groups of experiments were concerned with reparatory keratotomy in rabbits; the fifth group with homotransplants in rabbits, and the sixth group with heterotransplants in different animals. All the experiments were of the penetrating type. The corneal flaps made for the study of reparatory keratotomy, as well as the homotransplants, performed in rabbits, remained transparent. In a group of experiments

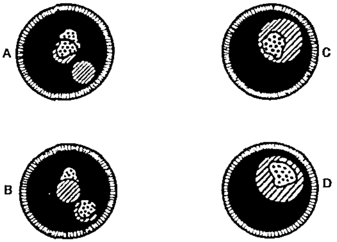

FIG 408 —Morax's method of lamellar keratoplasty by transposition. *A* and *B*: Gradle's method of circumscribed lamellar keratoplasty, *C* and *D* (Castroviejo.)

where heterotransplants were made in different animals, all the flaps opacified. On microscopic examination, Leoz Ortin and Tello found no difference between the transplants and the rest of the cornea. They also found complete nerve regeneration by a rapid infiltration of nerves coming from the cornea into the transplant until it was completely filled. The sections were stained by the reduced silver nitrate impregnation method of Ramon y Cajal. Leoz Ortin concluded that the best operation was autoplasty, that homoplasty was next in desirability, and also gave good results, and that heterotransplants always became opaque. He said that the most important thing is coaptation of edges and not of surfaces, and that nerve regeneration is very important for permanent transparency of the transplant.

Merz and Weigandt, in 1921, used the Von Hippel method, holding the transplant in place with woman's hair attached to the surrounding cornea on one side close to the transplant, and inserted into the conjunctiva at the limbus on the opposite side.

Ebelling and Carrell, in 1921, made a rectangular corneal flap (Fig. 409) with a cataract knife, making a step on the edges, which prevented the flap from falling into the anterior chamber. The flap was afterwards held in position by six sutures. When making the transplant, it was held with forceps, and olive oil was used after the operation, without dressing. Of 5 cats operated, the cornea of only 1 retained permanent transparency.

Gradle, in 1921, reported one case in which an operation was performed similar to one described by Kraupa in 1914, with the only difference that Kraupa's operation was of the penetrating type, and that performed by Gradle was of the lamellar type. In this case, there was no improvement of vision, because it was not possible to dissect the bottom of the opacity. However, the transplant adhered with complications. The operation consisted in making a flap (Fig. 408, *C*) with the aid of a trephine 7 mm. in diameter, including the opacity in the center of the cornea and a trans-

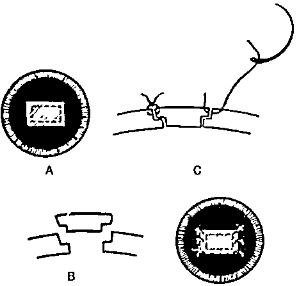

FIG. 409.—Ebeling and Carrel's method of circumscribed keratoplasty *A*, section of transplant; *B*, as fitted into position; *C*, sutures (Castroviejo.)

parent zone on the periphery. The incision penetrated only one-half the thickness of the cornea. This disk dissected with the aid of a Graefe knife, was turned 180 degrees in order to place the opacity toward the periphery and the transparent position in the pupillary zone.

In 1919 and 1922, Ascher, from Elschnig's clinic, wrote complete papers on keratoplasty, giving the results of such operation at that clinic. Later Elschnig, in 1920 and in 1922, Elschnig and Gradle in 1923, Stanka in 1927, Liebsch in 1929, and Elschnig again in 1930, presented reports of cases in which operation was performed in Elschnig's clinic following the technique of Von Hippel. These reports are really the most interesting in the history of keratoplasty up to that date, for they made it possible to study a sufficient number of cases so that conclusions of great interest for the solution of this important problem could be drawn. The report of Elschnig included all the cases operated in his clinic until 1930.

The technique used by Elschnig (Fig. 410, *A*) is a slight modification of

that of Von Hippel. Von Hippel's trephine of from 4 to 5 mm. in diameter is used to remove a tissue of full thickness from an opaque cornea, which is replaced by a similar disk of transparent cornea. A bridge suture is placed from the conjunctiva of the upper limbus over the transplant and tied in a similar position to the conjunctiva of the opposite side. Eserin is used before the operation, in order that the pupil will be contracted, protecting the lens from possible injury with the trephine. The operation is performed under local anesthesia. Palpebral akinesia, retrobulbar injection of procaine, and epinephrine and superior rectus suture, add safety to the operation. The transplant is obtained from a patient's eye or from eyes of adults or infants, enucleated shortly after death. Elschnig expresses the belief that any kind of solution hurts the transplant, therefore he keeps the graft between layers of dry cloth after it has been excised with the trephine.

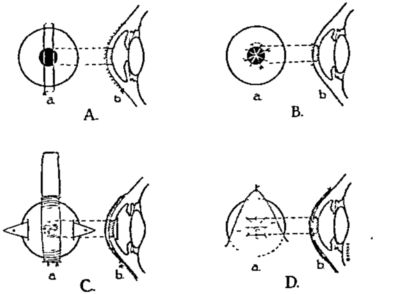

FIG 410 —Technique of circumscribed penetrating keratoplasty: *A*, Elschnig's; *B*, Thomas'; *C*, Filatov's, *D*, Castroviejo's. (Castroviejo)

Elschnig felt that the circumscribed penetrating keratoplasty of Von Hippel is the only dependable method. The opinion he expressed is that among patients with leukoma who are more than fourteen years of age, whose anterior chamber is normal, and who give no evidence of increase of ocular tension, keratoplasty will be successful in about 22 per cent of all cases, and that it will be successful in about 73 per cent of cases of interstitial keratitis. Transplantation material, he said, can be obtained from the eyes of young as well as of old persons with normal corneas; it is immaterial whether the remaining part of the anterior segment is normal or pathologically changed, or whether the donor has glaucoma or hypotension (phthisis bulbi). *He did not find any relation between hemolysis or agglutination of the serum and the transparency or opacification of the transplant.*

Lundsgaard in 1923, Filatov in 1925, 1927, 1928, and 1930, Frieberg in 1927, and Manes in 1929, presented other cases in which they had followed

the technique of Von Hippel, obtaining marked improvement of vision after the operation.

Foster, in 1923, reported six experiments on cats, in which an equilateral triangle was dissected (Fig. 411), one angle of which was beyond the center of the cornea. The flap obtained was turned in such a way that the central angle would move towards one of the peripheral angles in the hope that in human beings the central portion of the opacified cornea could be placed in the periphery. The flaps were fastened with penetrating sutures at each corner. Of the six grafts made in the eyes of cats, four remained transparent.

Majewski, in 1925, experimented on animals, using the 4 mm. trephine of Von Hippel to incise the superficial layers of the cornea, cutting the deeper layers with another trephine 3.5 mm. in diameter, making in this way a step which would prevent the transplant from falling into the anterior chamber.

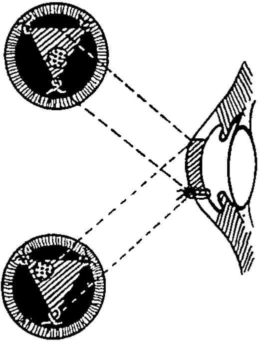

FIG. 411.—Foster's method of circumscribed penetrating keratoplasty (Castroviejo.)

In 1928 Filatov modified Von Hippel's operation, trying to eliminate its disadvantages, namely: the imperfect way in which the transplant is held in position, and the unfortunate way in which the iris and lens can be injured with the trephine. A flap is made in the upper part of the bulbar conjunctiva (Fig. 411), and an incision is made in the lower conjunctiva, near the lower limbus. With a cataract knife, a puncture and counter-puncture are made in the cornea, leaving therefore two parallel perforating incisions through which a strip of celluloid (prophylactic spatula) is passed, penetrating the anterior chamber and separating the cornea from the iris and lens. The leukomatous cornea is trephined and a transparent flap, taken from an eye of a patient, or from an eye enucleated from a cadaver shortly after death, replaces the trephined leukomatous disk. The con-

junctival flap, with its epithelial surface downwards, is stretched over the transplant and fastened with two sutures to the lower conjunctiva near the limbus. The strip of celluloid is then removed.

Since 1928, Filatov has published a number of papers dealing with corneal transplantation. In some of the papers (1935 and 1936) he described a new trephine (Filatov-Marzinkowsky), which is a combination of a hand trephine and a protective spatula which facilitates the performance of his operation. The trephine is constructed in such a way that drainage of aqueous humour, once the cornea has been perforated, is prevented. Filatov modifies his technique according to the necessities of the case. For instance, when it is impossible to use the conjunctival flap because of scar tissue changes, a small round piece of boiled egg's membrane with its inner surface towards the implant, is used instead. Bridle sutures are made in this egg membrane for better fitting and bridge incisions, in the manner of Elschnig, are placed vertically and horizontally for fixation both of the egg membrane and the implant.

If the incipient cornea is thickened by scar tissue and therefore presents an unfavorable field to receive the transplant, Filatov tries to improve the condition of the cornea. One of the methods he uses is to excise the leukoma, layer by layer, almost to the posterior ones on a large surface, and the wound is covered with the superficial corneal layers of another eye. The whole cornea is afterwards covered by a conjunctival flap. The purpose of such an operation is not to restore vision, but to create a better field for a later corneal transplantation.

When the leukoma is so thick that it is impossible to examine the anterior chamber, and the eye appears to have not only synechiæ but scar tissue, Filatov cleans the whole posterior surface of the cornea by exenteratio retocornealis anterior partialis. The technique improved by Filatov follows: (*a*) two stitches are made in the manner of Liegar; (*b*) a section is made along the limbus on two-thirds of its circumference; (*c*) the flap is turned up and cleaned from the synechiæ; (*d*) the scar tissue is cut with Graefe's knife and, without being pulled with forceps, is cut off with scissors so as not to injure the ciliary body. The vitreous usually escapes freely; and last, (*e*) the flap is put in its place, and the stitches are tied. If the eyeball collapses, an injection of physiological solution of sodium chloride is made. There is a certain risk in this operation, of course, but if the eye stands it well, there are chances for successful transplantation.

In regard to the material for transplantation, Filatov uses eyes enucleated from patients or eyes of cadavers enucleated shortly after death. The cadaver eyes have to be enucleated, according to Filatov, within a few hours after death. They may be used immediately after enucleation or preserved in citrated blood from the person from whom they were obtained, and kept at a temperature at from 4° to 6° C. above zero, to be used from twenty to fifty-six hours after death. Filatov found the corneas obtained from cadavers, even those preserved for a long time, to be just as good as those taken from living persons.

Filatov classified his cases as follows, according to the quality of the operative field: (*a*) in eyes with leukoma, complicated with glaucoma, buphthalmos, and symblepharon, corneal transplantation gives no positive results; (*b*) in rough cicatricial leukomas, only in a few cases can a permanent transparent transplant be obtained; and (*c*) successful transplants

may be done only in the case of leukomas in which some transparent corneal tissue remains. Filatov confirms the belief of Elschnig, that it is important to have corneal tissue in the leukoma in order to obtain successful corneal transplants.

From 1923 to 1935, 205 operations have been performed in the ophthalmologic clinic of the Medical Institute of Odessa. Only 96 of these have been completely studied by Filatov; 14 cases preserved a permanent transparency of the graft. They were observed from one to six years, except for one patient who died seven and a half months after operation.

In 1930 Thomas described a new modification of Von Hippel's technique (Fig. 410); its main features were to outline a disk with a trephine from 4 to 4½ mm. in diameter in the leukomatous cornea of the host. Then the trephine is sloped to 45 degrees and rotated, so as to cut through at one point. To this point one blade of a scissors penetrates into the anterior chamber and the remaining inner layers of the outlined corneal flap are cut in a shelving manner, so that the endothelial aspect of the disk is smaller than the epithelial surface. With a trephine slightly smaller than the one used in the host, a similar disc is obtained from a transparent cornea The leukoma is replaced by the graft and is kept in position by cross stitches previously inserted into the cornea a short distance from the graft itself. The pupil is dilated with atropine.

Thomas attaches considerable importance to the size of the transplant and its relation to the size of the defect. The transplant should be smaller than its bed, since the former undergoes some swelling and if it is originally of the same size as the latter, the result is a bulging cicatrix with irregular edges. In Thomas' technique the transplant is firmly held in position by cross stitches. The shelving of the transplant prevents it from falling into the anterior chamber and the dilated pupil prevents anterior synechiæ The transplant is obtained from eyes of patients and is kept in olive oil for a short while before it is finally placed in the eye of the host.

Since 1930, Thomas has published a number of papers reporting successful corneal transplantations both in animals and human beings operated upon following his technique. By 1937 Thomas had already performed 36 operations in 32 eyes, the graft remaining transparent in 83 per cent of the favorable cases.

Experimenting with heterogenous grafts in rabbit eyes, Thomas, in 1935, arrived at the conclusion that heterogenous grafts should not be used for corneal transplantation in man.

In 1932 the author (Castroviejo) reported a new technique of partial penetrating keratoplasty in which a high percentage of transparent transplants was obtained in animals. The operation consisted in outlining, with the aid of a double-bladed knife, (Fig. 413), a rectangular corneal flap in the eye of the host, finishing the dissection of the flap with keratome and scissors. In such a way bevelling of the flap was obtained with its inner surface smaller than the outer surface, to prevent it from falling into the anterior chamber. A graft obtained following the same technique was held in position by means of two conjunctival flaps dissected from the upper and lower bulbar conjunctiva, and sutured in the center of the cornea along the horizontal diameter. The experiments were performed on 82 animals with normal corneas, chiefly rabbits, exchanging transplants between them. Three dogs were used for the purpose of determining the

possibility of heterotransplants, exchanging corneas with 3 rabbits. Forty operations were performed following the technique.

Thirty-five per cent of the transplants retained permanently the appearance of normal cornea, both clinically and histologically. In 1934 the operation was modified, making the transplant quadrangular instead of rectangular. The operation was tried out in 17 rabbits in which corneal leukomas had been produced by lime burns. The transplants (homotransplants) were obtained from rabbits sacrificed shortly before the operation. The author's (Castroviejo) technique of circumscribed penetrating keratoplasty varied from all others hitherto described in two fundamental points; namely, the shape of the graft and the manner of dissecting it, and the manner of holding the graft in position. In regard to the shape of the transplant, the rectangular flaps are better than the circular ones to obtain bevelling of the transplant and thus preventing it from falling into the anterior chamber. The combination double knife-scissors gave cleaner sections than the trephine-scissors combination used by other authors. Microscopic examination proved that linear sections performed with knives, and knife combined with scissors, had cleaner edges than those made by

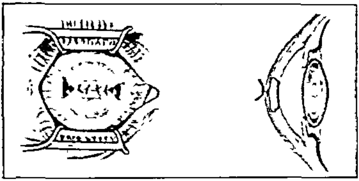

Fig. 412.—Castroviejo's operation (1934).

trephine. The cutting of the edge of circular flaps with scissors was found to become progressively more difficult, as the diameter of the circle diminished. *In regard to the conjunctival flaps, the claim was then made that* conjunctival flaps carried over the graft offered the best means for holding the graft in position, giving desirable gentle pressure and offering the best possible protection for the eye (Fig. 412). The conjunctival flaps nourished the graft during the first few days and accelerated the healing process of an avascular tissue such as the cornea. These flaps were particularly useful in cases of dense leukomas, where nutrition of the graft was greatly impaired. Finally the conjunctival flaps offered the best possible protection for the graft, and the eye in case the former became partially detached or did not heal. In 1934 7 cases were reported on human beings with leukomatous corneas operated with the same technique employed in the eyes of rabbits. Of the 7 cases, 3 retained permanent transparency of the graft.

By 1936 the author (Castroviejo) had performed 21 operations on human beings. In one of these cases, the transplant failed to adhere. It was concluded that, although conjunctival flaps seemed to be the ideal means to

apply a uniform pressure on the transplant, this pressure, due to the elasticity of the conjunctiva, was not sufficient to prevent displacement of the transplant, especially in unruly patients. Also it was found that in certain cases where the conjunctiva was badly scarred, it was difficult to dissect two conjunctival flaps. From then on the operation was modified. The transplant was held in position (Fig. 410) with a continuous suture, and when the conjunctiva was so scarred that the dissection of two conjunctival flaps was no longer possible, the transplant was covered with one flap of conjunctiva obtained from above, below, temporally, or nasally; that is, from the place best suited for the dissection of this flap. The conjunctival flap was sutured to the episclera near the limbus and covered the whole cornea.

After further research in animals, and 30 more operations in human beings, it was decided that conjunctival flaps had a tendency to become infected, especially in animals, and prolonged the postoperative course, leaving the eye irritated for a larger period of time than when they were not used. It was also found that transplants remained clear during the first few days under conjunctival flaps, justifying the belief that they were kept alive under ideal conditions of nutrition, while grafts in which conjunctival flaps had not been used, presented during the first few days a diffuse, bluish-gray appearance, almost opalescent in some marked cases, due to edema. However, the ultimate fate of the transplant, and whether

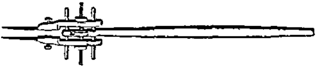

FIG. 413 —Castroviejo's double-bladed knife

it remained transparent or became opaque, depended more on the nature of the surrounding tissue of the host than on the appearance of the graft during the first few days. If the transplant is surrounded by a dense leukoma which greatly impairs the nutrition of the graft, (while it may look perfectly transparent for a few days and may remain so during a few weeks or months), the transplanted tissue finally becomes either nebulous or opaque. On the other hand, when the graft is surrounded by host tissue preserving a great percentage of healthy corneal elements, the transplant may look edematous the first few days if conjunctival flaps are not used, but generally the edema will disappear in about six to eight days, the graft retaining thereafter a permanent transparency. Another observation made was that when an excessive bevelling was made in preparing the transplant this had a tendency to protrude; and finally it was also observed than when two separate sutures were used to hold the transplant in position, occasionally one of the sutures had a tendency to press upon the transplant more than the other, thus developing lines of uneven pressure upon the transplant with a tendency for the latter to have an uneven coaptation in certain portions of the edges of the transplant and cornea of the host.

On account of the above-mentioned observations, the author (Castroviejo) again modified his operation in 1937. In more than 200 cases oper-

ated since the last report was made, the technique employed was as follows. The pupil is widely dilated with atropine. The leukomatous area of cornea to be removed is outlined with a double-bladed knife (Figs. 413, 414, A) without penetrating into the anterior chamber. (Fig. 414, A, B, and C). A continuous corneal suture is inserted outside the edges of the outlined square (Fig. 414, D). This suture will be destined to hold the transplant in position. Another suture is inserted within the outlined leukoma to

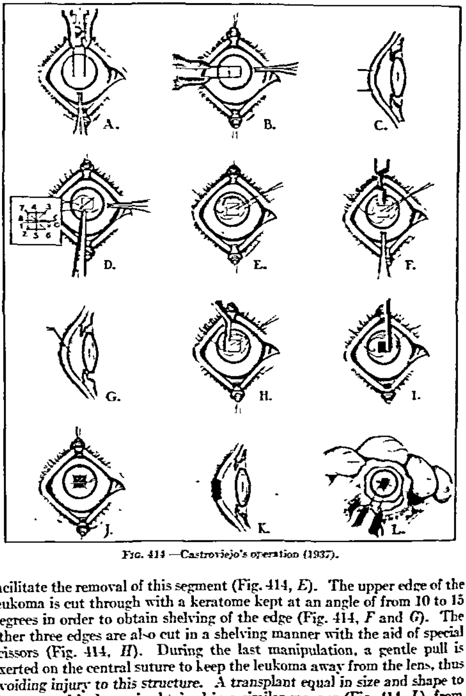

FIG. 414 —Castroviejo's operation (1937).

facilitate the removal of this segment (Fig. 414, E). The upper edge of the leukoma is cut through with a keratome kept at an angle of from 10 to 15 degrees in order to obtain shelving of the edge (Fig. 414, F and G). The other three edges are also cut in a shelving manner with the aid of special scissors (Fig. 414, H). During the last manipulation, a gentle pull is exerted on the central suture to keep the leukoma away from the lens, thus avoiding injury to this structure. A transplant equal in size and shape to the removed leukoma is obtained in a similar manner (Fig. 414, L), from

the enucleated eye of a patient or from the eye of a stillborn infant enucleated shortly after delivery and kept from one to forty-eight hours in Ringer's solution at a temperature of 2° to 3° C. above zero. The clear transplant replaces the dissected leukoma (Fig. 414, *I*) and the continuous corneal suture is made tight, taking care not to exert excessive pressure upon the transplant (Fig. 414, *J* and *K*). With the aid of a spatula passed between the spider-web-like suture and the transplant, care is taken that pressure is evenly distributed.

The operation may be performed under local or general anesthesia. With coöperative patients local is to be preferred. Local anesthesia is obtained by repeated instillations of cocain 2 per cent and adrenalin 1 to 1000 for about one-half hour before the operation. Paresis of the orbicularis with novocain 2 per cent and retrobulbar injection of novocain and adrenalin add to the safety of the operation. Using the technique just described the author has operated 8 times in children under ten years of age and once in an adult of eighteen years using general anesthesia. The postoperative course was uneventful and followed the same course as those operated upon under local anesthesia.

The first dressing is performed two days after the operation and atropine is instilled. From then on every two days the dressing is changed and the instillation of atropine is continued. From the sixth to the eighth day after the operation, the suture is removed under local anesthesia in cooperative patients and under general in unruly patients. On the tenth day the unoperated eye may be uncovered and the patient may be allowed to get out of bed. By the fourteenth day the operated eye may also be uncovered. Atropine may have to be continued if the eye has remained irritated. As soon as all signs of inflammation have disappeared, atropine may be discontinued. The patient is given a fluid diet the first two days, semifluid during the following four days and then gradually returned to a normal diet.

In recent years the author (Castroviejo) has done considerable work with good success with a round trephine for cutting the graft, as well as for removing that section of opaque cornea for the reception of the graft. The retaining suture is placed exactly the same for this graft as for the rectangular transplant.

During the past eight years, more than 500 operations have been performed at the Institute of Ophthalmology, Columbia-Presbyterian Medical Center, employing the original technique of the author (Castroviejo) or its subsequent modifications. Unselected cases were operated upon early in the history of this surgical research in order to determine which cases would and which would not benefit from surgical intervention. According to this experience cases for corneal transplantation may be classified into two categories, favorable and unfavorable. Those cases are favorable in which (1) there is normal intra-ocular tension; (2) the diseased ocular tissue is limited to the cornea; (3) the leukoma is not very dense (although it may be sufficient to cause considerable impairment of vision); and (4) there are areas of clear or slightly scarred cornea surrounding the graft.

Unfavorable cases include (1) those with very dense leukomas extending over the whole or almost the whole cornea (in these cases the transplant would be entirely surrounded by dense scar tissue); (2) those with aphakia; (3) those with increased tension; and (4) those cases of corneal cloudiness with densely vascularized pannus.

When the operation is performed on favorable eyes, a high percentage of success may be expected (over 85 per cent) with permanently clear transplants and considerable improvement of vision. In 2 of the cases operated, vision improved from perception of hand movements at 1 foot to 20/20.

The early work done on keratoconus (see earlier editions of this section) has *demonstrated that keratoplasty is a sound surgical procedure for this* condition. This can be easily understood because the corneal tissue surrounding the corneal transplant is usually healthy, and frequently, at the junction of the transplant and the recipient cornea it is of normal thickness.

On those eyes in which the anterior segment of the eyeball is severely affected, such brilliant results cannot be expected, but a definite *improvement can be obtained when a suitable technique is used.* Inasmuch as the eyes have little or nothing to lose and may be considerably improved, the operation is justified. In this group of unfavorable eyes, preliminary operations must be performed before corneal transplantation, in order to prepare the eye for a more successful final keratoplasty.

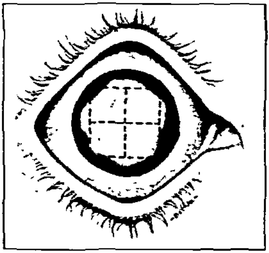

Fig. 415.—Illustrating the manner in which an extensive corneal leukoma may be replaced for a more permeable tissue by performing successive corneal transplantations in mosaic. (Castroviejo.)

The preliminary operations required on some of these eyes are: operations to combat glaucoma; removal of synechiæ whenever possible; preliminary iridectomy when the pupil does not dilate readily; the removal by electrocoagulation, or any other method (such as partial or total superficial keratectomy), of the thickest vessels in cases of pannus (whether the pannus is a sequela of trauma or disease; and *resections of segments of cornea,* in order to obtain an approximately normal curvature when staphyloma is present. Finally, in cases where the whole cornea has been transformed into dense scar tissue, it will be necessary to perform first a series of transplants in mosaic (Fig. 415) in order to replace the densest scar extending throughout the cornea by a more permeable tissue, and then perform the last corneal *transplantation for visual purposes.*

The operation of total superficial keratectomy for the removal of pannus due to injury as preliminary to corneal transplantation, consists in making two incisions across the entire cornea at right angles to each other, and

dissecting the four sectors of the cornea thus outlined with the edge of a cataract knife held flat against the corneal surface, so as not to perforate. The dissection is carried from the center of the cornea across the cornea to the periphery (Fig. 416). The operation may be combined with peritomy; this seems to give more satisfactory results. This type of operation always leaves some degree of corneal opacity, even in cases when the underlying corneal tissue is normal or almost normal, largely defeating the operation for visual purposes and necessitating a corneal transplantation to obtain a greater improvement of vision.

Corneas obtained from stillborns or infants who died a few hours or a few days after delivery are as good as those obtained from enucleated eyes of adults, provided the material is obtained shortly after delivery or shortly after the death of the infant.

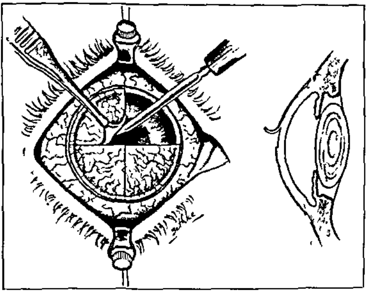

FIG. 416 —Total superficial keratectomy combined with peritomy for the treatment of corneal scars and pannus (Castroviejo.)

In the last three or four years the interest of ophthalmologists in the treatment of corneal opacities by corneal transplantation seems to have awakened, and numerous reports of keratoplasties have appeared in the literature. Among those who have reported successful corneal transplantations in the last few years are Friede, Strachow, Ricroft, Wright, Wasjutinsky, Sterenberg, Nazarov, Towbin, Feldman, Francheschetti and Streiff, Kirwan, Nizetic, and Ochy. Some of these authors used the original technique of Von Hippel, others used the techniques described by Elschnig, Filatov and Thomas, and still others used slight modifications of these techniques.

Present Status.[1]—From the analysis herein presented, which contains the experience of most men interested in corneal transplantation in the past, the present status of keratoplasty may be summarized as follows:

1. Total keratoplasty offers only a temporary improvement of vision.

[1] AUTHOR —This following summary undoubtedly brings the subject of keratoplasty, and factors connected with it, up to date, authoritatively.

All the cases reported in the literature of this type of operation have resulted in failure. The implant invariably becomes opaque and the eye is in danger of being lost through secondary glaucoma or phthisis bulbi.

2. Circumscribed or partial lamellar keratoplasty is applicable only in cases in which the lesions are very superficial. Superficial lesions rarely extend over the whole surface of the cornea, and optical iridectomy could often be performed in those cases instead of keratoplasty. When the opacity is very extensive, and yet superficial, it may be necessary to perform a keratoplasty operation of the lamellar type although the formation of connective tissue at the base of the transplant often defeats the success of the operation for visual purposes.

3. Circumscribed or partial penetrating keratoplasty has offered up to the present day the best permanent results.

4. In regard to the technique of the operation, it may be said that the person accustomed to use any particular method will probably obtain better results using that method than if he were to use other procedures in which he has had less experience. Those interested in corneal transplantation should familiarize themselves with the different techniques and select the one that is best adapted to them.

5. Corneal transplants can be performed at any age if methods are used which can secure the transplant in position, thus preventing the detachment of the transplant in unruly patients. Infants with corneal opacities as sequela of ophthalmia neonatorum should be operated upon as early as possible to prevent amblyopia ex anopsia.

6. Transplantable material for keratoplasty may be obtained from adult eyes which have to be enucleated for various reasons, and which have normal corneas, as well as eyes from cadavers and stillborns, enucleated shortly after the death of the patient or the delivery. If the eyes are not to be used immediately, they may be kept for two or three days with viable corneas in Ringer's or normal salt solution at a temperature of about 2° or 3° C. above zero. (From work which has been recently done in controlled experiments on the homo-transplantation of preserved corneæ by Fine[1] it seems that while corneæ which were preserved for twenty-four hours gave results similar to those obtained with fresh corneæ, yet the preservation of corneæ for forty-eight hours or more seemed to jeopardize the chances for successful transplantation.—AUTHOR.)

7. In corneal transplantation, improvements of techique have made it possible for a good many of those unfortunate ones, who heretofore were doomed to permanent blindness, to regain vision.

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BAND SHAPED KERATITIS. DYSTROPHIES

This condition develops only in a degenerated eye. It is often seen in the partially collapsed eyes following unsuccessful trephining for buphthalmos. It has been reported in a degenerated eye following atrophy of the globe with essential atrophy of the iris, in old cases of absolute glaucoma, and in similar chronic conditions. Stripping of the superficial lamellæ of the cornea has been attempted in these with but poor success. The dystrophic condition returns because the underlying cause continues. In the final analysis, the only surgery recommended for it is that of enucleation, or some substitute operation for this. An optical iridectomy may save some vision for many years.

The various forms of corneal dystrophy, especially those of a familial character are not surgical problems. Keratitis bullosa usually has an unfavorable prognosis, but treatment should not be denied to relieve the irritation; the larger vesicles should be opened and their anterior wall removed; the surface of the cornea scraped lightly to Bowman's membrane and then tincture of iodine U. S. P. applied. Cauterization with the actual cautery loop will occasionally assist in healing and in preventing recurrences; repeated corneal paracenteses have proven of value; and iridectomy, at times, seems to check recurrences. Frequently, an enucleation seems necessary to relieve the patient of pain, especially in degenerated eyes.

PANNUS

The surgery of pannus is a matter of delimiting keratotomy at the limbus and it is sufficiently often successful to be well worth trying. Before any surgery is done every effort should be made first to remove the cause of the corneal vascularization. This applies especially to trachoma, for it is fruitless to hope for improvement with a peridectomy in the presence of a thick and deformed upper lid. Logical surgery here would be tarsus and superior cul-de-sac resection. Small areas of pannus formation, especially those connected with old injuries, can be improved to a considerable degree through corneal pasteurization. More extensive pannus demands peritomy or peridectomy. The surgery of these has been considered in the section on the surgery of the conjunctiva.

LIMBAL STAPHYLOMATA OR ECTASIA OF THE CORNEA. KERATOCONUS

Staphyloma of the cornea may be partial or complete. Partial staphylomata are usually post-traumatic and are correctible by surgery, especially limbal staphylomata from perforating injuries of the globe near the limbus. The conjunctiva is to be released, at the site of the staphyloma so that a van Lint conjunctival flap may be formed, and a small von Graefe knife passed, from limbus to limbus through the anterior chamber, just below

the level of the anterior leukoma and the staphyloma. The knife is then *carried through to the limbus emerging there without a conjunctival flap.* The severed pillars of the iris are moved away from the staphyloma, even increasing the size of the iridectomy, if this is necessary, by the resection of a very small amount of iris at each pillar. A triangle is then resected from the cornea, base at the limbus, apex into the cornea, thus removing the major portion of the staphyloma with the adherent iris. The apex of the triangle should pass into healthy cornea, if it is possible. Fine waxed silk sutures are to be passed between the edges of this triangular resection so that, when subsequently tied, the two lips of this triangular resection may be closed. The iris is again inspected to be sure that its pillars are free and these two sutures then tied. They must be placed in the cornea rather firmly so that they will not tear out prematurely. The sutures need to include about two-thirds of the thickness of the cornea and not the total thickness. Each suture is tied firmly and reinforced if necessary by an additional suture to one side of those just placed. The sutures are then cut short and the conjunctival flap brought up over the cornea until it is well beyond the end of the corneal incision line.

Naturally, considerable irregular astigmatism developed in these cases but the eyeball has been saved with fair vision remaining. After atropinization a postoperative pressure dressing is applied; the eyes being dressed for the first time on the third day. Foreign protein therapy should be used in these cases.

De Schweinitz[1] recommends Berry's operation for partial staphyloma. In this, a knife needle is introduced through the base of the staphyloma and held in one hand. An elliptical piece of the cicatricial tissue which forms the staphyloma is next removed on each side of the needle with a cataract knife, by two converging incisions, in such a manner that the portion held by the needle and consequently the needle itself is cut out. Fine silk sutures are used to unite the wound and this covered with a conjunctival flap.

Ziegler's stellate keratectomy for anterior staphyloma is to be performed with a small scleral punch. The technique is as follows. A vertical incision is made through the base of the staphyloma. The inferior blade of a punch is passed into the anterior chamber and beneath the cornea. The punch is closed and the left lateral lip is excised. In a similar manner the right lateral lip is also removed. Next the upper margin of the oval wound is grasped at its center by the punch and a vertical section excised. A trifoliate-shaped wound as in Figure 417 will remain. This is closed by two fine corneal sutures passed as illustrated and tied. A conjunctival flap should be used to cover the entire corneal wound. *In all cases of surgery,* for a partial staphyloma, an iridectomy should be done either preliminary to, or as a part of, the above surgery itself.

Complete corneal staphyloma is in most instances a hopeless condition. An enucleation or one of its substitutes is usually the best surgery for it. De Wecker resected the staphyloma at its base with scissors, placed 4 to 6 sutures, ready for immediate tying, extracted the lens through this incision, tied these sutures, and closed the conjunctiva over the large wound formed in the cornea. Beer's method was the same but he resected the staphyloma without subsequent conjunctival flaps. In the largest number of instances,

[1] Diseases of the Eye, 10th ed., W. B. Saunders Company, 1924.

such surgery results in infection of the vitreous and a panophthalmitis. Czermak and Knapp operated on these cases according to Berry's method, as he applied it to partial staphylomata. Except in their instances of complete staphylomata, a greater portion of the cornea is removed and the corneo-scleral defect closed by conjunctival-scleral sutures, using either waxed silk or fine catgut sutures. In extensive staphylomata the conjunctival-scleral sutures must be introduced before the staphyloma has been ablated.

In general, ectasia of the cornea may be divided into either inflammatory or non-inflammatory origin. Incomplete corneal staphylomata or ectasia is usually of inflammatory origin. Keratoconus and keratoglobus, ectasia of non-inflammatory origin are often considered together under the name of "staphylomata pellucidum," in that they are more or less transparent, and under this designation are readily differentiated from cicatricial staphyloma of traumatic and inflammatory origin. Keratoglobus is usually but one of the symptoms of buphthalmus, and for that reason any consideration

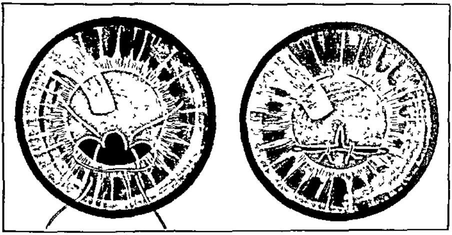


FIG. 417.—Ziegler's staphyloma resection

of it is to be included under the discussion on buphthalmus. Keratoconus is somewhat rare. Vision is grossly impaired by reason of the axial myopia and irregular astigmatism, the bulging of the cornea is not aspherical, and in addition, the apex of the cone becomes opaque, still further reducing vision.

The condition may range from a very slight degree with the cornea perfectly transparent, to that of very high degrees with the apex opaque, the cornea considerably thinned out, and with many irregularly stellate lacerations in Descemet's membrane. In addition, ulceration may occur, late, at the apex of the cone, and the eye ultimately is lost through panophthalmitis.

Terry and Chisholm[1] recently discussed in great detail the effect of pressure on the treatment of keratoconus. According to Terry and Chisholm, as the essential lesion appears to be an abnormal yielding of the central portion of the cornea with a thinning in the center, with or without gaps in Bowman's membrane, and with a tendency of the deeper layers of the corneal stroma at the apex to split with the formation of unusually

[1] Am. Jour. Ophth., Ser. 3, 23, No 10, 1089, October, 1940.

large lacunæ, and with or without gaps in Descemet's membrane, in the region of the ectasia. They felt that a pressure treatment utilized so successfully as an accessory treatment in many other operations should be applied here. This is especially significant in that Knapp[1] had earlier

FIG. 418.—Pressure dressing according to Terry and Chisholm for keratoconus. (Terry and Chisholm, courtesy of Am. Jour. Ophth.)

recommended continued pressure by means of the firm monocular bandage for from five to six weeks, with continuation of the pressure during sleep for six weeks longer, following cauterization treatment of the keratoconus.

[1] Trans. Am. Ophth. Soc., 27, 63, 1922.

The technique of the application of the treatment is illustrated in Figure 418. The authors are very particular in the application of this pressure bandage, as they outlined it, because several less effective methods are in general use. The bandage is changed daily for one week, after which time the intervals between dressings may vary from two to four days. At various intervals, molds of the cornea may be made to show what progress is achieved. If there is no definite reduction in the amount of the corneal deformity in seven to ten days, there appears to be but little hope of obtaining any beneficial results. Omitting the pressure perhaps, because of intercurrent complication, delays desirable results. If the interruption, however, is not too long, the primary beneficial result may not be wholly lost. The conclusions of Terry and Chisholm in part follow herewith, verbatim.

The fact that small degrees of keratoconus are relatively frequent is observable upon painstaking examination of many patients with over three diopters of astigmatism, especially if one meridian of the error of refraction is myopic.

The development of keratoconus lacks sufficient irritation to stimulate scar-tissue formation until late in the growth of the deformity

Pressure treatment, the full value of which has hitherto been unrealized, does reduce the deformity in some instances and gives permanent cure of the disease if the pressure is maintained sufficiently long (at least ten weeks) to allow scar-tissue repair to mature enough to hold the newly attained more or less normal thickness of the cornea.

The eye rotates freely under the pressure bandage.

The cure of the corneal deformity may arise (*a*) through irritation and a reaction of fibrous-tissue growth brought on by almost continuous change in the pattern of folds and wrinkles of the cornea under compression incident to rotation of the eye, (*b*) through the normal tendency of the cornea and sclera to contract and thicken when intra-ocular pressure is lowered indirectly by greatly elevating the extra-ocular pressure by means of the pressure bandage.

Complications of variable importance commonly met with in pressure treatment are corneal scar (in all cases), ciliary injection, and spastic miosis during the period of treatment, vascularization of the cornea, and erosion of the cornea.

Since the pressure bandage is to be used for ten weeks, it must be applied more carefully than usual to avoid skin irritation and chafing of the forehead and ears

Pressure treatment at the present time should be limited to patients who have keratoconus of considerable amount with reduced visual acuity not improved materially by contact glasses.

In selected cases, keratoconus may become a surgical problem. Formerly, before the era of contact glasses, it was wholly surgical. The medical treatment of keratoconus is not clear as to procedure nor definite as to results. Certainly many cases remain stationary, not because of the procedures outlined, but in spite of these. Still other cases have progressed to ulceration and to panophthalmitis when under the best of professional treatment. A properly fitting contact glass usually gives the patient a maximum of visual acuity, and also seems to halt the further progress of an occasional case.

A note relative to contact glasses is relevant here. The usual solutions used for these are either an isotonic salt solution or a saturated solution of boric acid. Both are in error. They become irritating, and the patient cannot retain the contact glasses for any great length of time. Buffer solutions if used instead are non-irritating, fungi do not develop in the stock solutions, and irritation being at a minimum, the patient can often retain the contact glasses without discomfort and without corneal involvement for from eight to fourteen hours. The Buffer solution as recommended by

Gifford,[1] with a pH 7.6, is non-irritating and is "to be used instead of boracic acid alone as it is less irritating, . . . and such solutions remain clear and free from bacterial growth without the addition of any antiseptic. These are mixed, 50 parts of No. 1 to 1 part of No. 2, the result is neutral in reaction or at the most more slightly alkaline." The use of contact glasses demands unceasing attention on the part of the patient to the prevention of irritation and to absolute asepsis. Patients have returned, after the use of a contact lens for several years with a deep central corneal ulcer, with hypopyon, and with impending loss of the eyeball undoubtedly from lack of necessary asepsis.

One solution consists of	Boracic acid	6.2 gm.
	KCl	7.4 gm.
	H_2O	1000 cc.
and the other of	Na_2CO_3	21.2 gm.
	H_2O	1000 cc.

The many different procedures advanced for the surgical treatment of keratoconus suggest a general lack of value. The procedures consisted of the resection of a wedge- or a triangular-shaped piece of cornea from the apex of the cone, allowing the wound to heal, either with or without sutures; or a similar procedure combined with a conjunctival plastic flap, or the use of cauterization over the entire tip of the cone. In some instances this was also accompanied by a conjunctival flap. Median tarsorrhaphy was recommended by some, external angle canthotomy by others, and in many instances an optical iridectomy, to evade the subsequent resulting leukoma, gave maximum visual correction. Beard has reported several very good results following discission of the lens combined with the use of atropine and pressure bandages. He states: "the ultimate flattening of the corneas was truly remarkable." Meller recommended the treatment of these cases by trephining alone or trephining combined with cauterization. The consensus of opinion seems to be slowly swinging away from surgery for these cases.

According to the earlier reports and surveying them critically, it seems that when surgery is indicated, the procedure to be used should be one capable of the fewest possible complications. Sharp dissection, resection of the cornea, or cautery resection of a portion of the cornea is not recommended, even though good results have been reported. Corneal scleral trephining alone has been of proven assistance, though in such instances, as soon as the anterior chamber is reformed superficial cauterization of the cone also may be carried out. Elschnig[2] developed first, a sound surgical treatment of keratoconus, one which utilizes *surgical cauterization. His* technique has the least dangers connected with it and the results he reported were good. Elschnig used the flat electrode upon the apex of the cone and continued the cauterization from the apex of the cone toward the limbus, even to the limbus, at that portion nearest to the apex of the condition. He felt that early vascularization of the cauterized area was the reason for the successes he obtained. The scar which resulted did not encroach further upon the pupillary area than the original position of the summit of the keratoconus, and he stated that the broad band of cauterization from the apex toward the limbus was a definite factor in obtaining a flattened cica-

[1] Gifford, Ocular Therapeutics, Lea & Febiger, 1942.
[2] Wien. klin. Rundschau, p. 20, 1904.

trix. The pupil should be contracted with eserin and the apex cauterized with a dull cherry-red ball-shaped or flattened disk-shaped electrode. The anterior chamber may perforate and if so, further cauterization cannot be continued at this time. If this does not occur, the cautery tip is then stroked from the site of the original cautery toward the limbus to form a broad band or "bridge-like extension." Atropine is then instilled, the eye is bandaged, and the patient must remain in bed until complete healing has occurred. A daily change of dressings, irrigation of the cul-de-sac, continued atropinization, and a pressure bandage are quite essential The atropine should be discontinued as soon as the danger of anterior synechiæ is passed. Eserin should be used thereafter at the time of the dressings. A month's stay in the hospital is a conservative estimate of the time which this procedure will consume.

Cauterization with a conjunctival flap has also been recommended This is a bit more dangerous in that it involves deliberate perforation of the cornea by cautery with a subsequent flap. Gruenert described an extensive and formidable procedure for this. A modification of it, utilizing a recommendation of Knapp[1] has been used by the author several times in the treatment of traumatic conditions of the cornea, especially wartime injuries While these, in the final analysis, were cases of keratocele, the procedure may lend itself to keratoconus. For the operation, the pupil should be contracted with eserin at a maximum. The conjunctiva at the limbus is then dissected so that it can be moved over the cornea as a van Lint flap. The sutures for this are inserted but not tied. A 2 mm ball-tipped cautery is then placed cold upon the cornea, the current turned on, and by slow adjustment of the rheostat the cautery tip is permitted to come to a cherry-red glow. The ball tip of the cautery is held in contact with the cornea until a minimal perforation has occurred. (Knapp in his original article felt that an overheating of the aqueous might occur as a result of this procedure, with subsequent damage to the lens and to the iris. It is doubtful whether this actually does occur, in that the entire procedure need not consume more than thirty seconds, and as soon as the perforation does occur, the aqueous gushes out and the anterior chamber becomes lost.) The surgeon should be certain that there is no prolapse of the iris through the perforation. As soon as this point is assured, the sutures in the conjunctival flap are tied, a 2 per cent atropine ointment is instilled and the eye closed for twenty-four hours. If the iris appears incarcerated or the anterior chamber is not reformed at the end of the time, the atropinization should be augmented by the use of glaucosan, either by instillation using the laevo-rotatory form, or by subconjunctival injection, using, in this instance, the dextro-rotatoric form. A pressure dressing should be applied each day, and the case should be dressed daily. The pressure dressing may be discontinued as soon as the eye is white. The conjunctival flap will slide back of itself, and at that time the conjunctival sutures should be removed. If there is any adhesion of the conjunctival flap to the area of the corneal cauterization, this must be sectioned. When the pressure dressings are discontinued, a median tarsorrhaphy should be done and retained for from three to six months. Terson was the first to make this suggestion.[2]

Considering everything there is no doubt that a corneal transplant as

[1] Norris and Oliver, Disease of the Eye, p. 825

[2] Terrien, Chirurgie De L'Oeil, Paris, Masson et Cie, p. 41, 1921.

outlined by Castroviejo is one of the best treatments for keratoconus; in fact this condition is almost ideal for the technique.

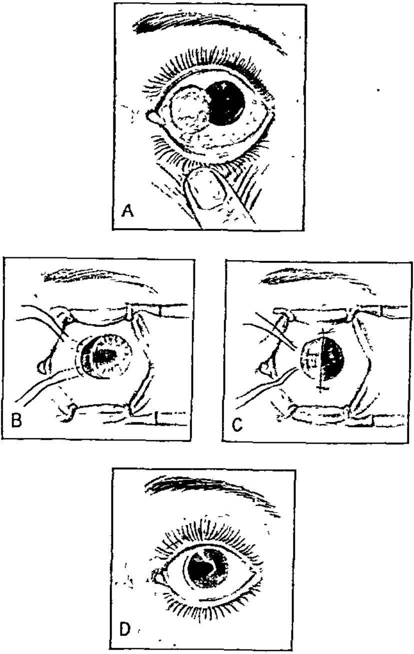


FIG. 419.—*A*, case of post-traumatic limbal staphyloma (limbal ectasia), cystic, non-filtering iris ciliary body incarceration. Original trauma blow to eye with screw driver with subconjunctival limbal rupture; *B*, corneal scleral closure (see section Cataract Surgery, Stallard's suture), conjunctiva for suitable flap, *C*, flap in position, conjunctival exit for corneal scleral sutures, *D*, end result.

Postoperative staphylomata occasionally occur after cataract extractions. An iris prolapse occurs, the corneo-scleral incision line begins to gape, and shortly after that a juxtalimbal staphyloma begins to develop. The

pupil will be drawn up, the eye become irritable, and further surgery is necessary to save the eye. (This condition will be referred to again in the section on surgery of the iris.) The postoperative treatment of these conditions, while not simple, is usually fairly satisfactory. It is not uncommon to obtain a quiet eye, with normal tension and with 6/15 to 6/22 vision after the correction. Because of the danger of vitreous prolapse during repair, the repair surgery is best done under avertin anesthesia, augmented as is necessary by local anesthesia and by venethene. The conjunctiva above the staphyloma is incised in a crescentic manner and mobilized for a large subsequent flap. The staphyloma is then opened with sharp scissors and the entire iris prolapse cleanly removed with de Wecker scissors, the operator being careful not to damage the ciliary body. The resection of the iris prolapse may be sufficient to permit relaxation of the iris and the return of the intact sphincter iridis to a central position. Figure 419 shows such a post-traumatic staphyloma treated in this manner; however, in resecting this staphyloma, it was certain that a small portion of the ciliary body was involved in the staphyloma and was resected with its removal. (See section on Sympathetic Ophthalmia.) De Wecker scissors are introduced into the anterior chamber, with the blunt-tipped blade beneath the level of the iris and the pointed blade above. A straight incision is made across the pupil, sectioning the sphincter of the iris below, and the organized exudate in the pupillary aperture. This will result in a V-shaped pupil apex downward. The bridge of conjunctiva which was formerly covering the gap at the corneo-scleral junction must then be removed. The pillars of the iris are again readjusted and any hæmorrhage and débris irrigated from the anterior chamber. Two 6-0 waxed black silk sutures are inserted by delicate but firm bites passed from the edge of the corneal lip to the bared scleral lip of the original corneo-scleral incision line. Both sutures should be inserted before either is tied. They must be accurately placed so that the corneal lip lies flat against the sclera. The ends of these two sutures are tied and cut short; then the conjunctival flap is to be brought down and sutured slightly past the mid-line of the cornea. It may be wise, after the removal of a large staphyloma as illustrated, (Fig. 419), to plan a scleral-corneal suture bridging the scleral-corneal defect. This, using a similar suture, is first passed through the conjunctival flap, (before it is tied down into place) then a bit of scleral lip, from thence a corneal bite, similar to the Stallard suture, thereafter, another scleral lip bit, and the suture emerges through the conjunctiva close to its point of entrance. After the conjunctival flap is tied (or even before) this suture closes the gap between sclera and cornea, and its external knot permits easy removal later. Atropine ointment is instilled and both eyes are bandaged, the bandage on the operated eye should exert a slight amount of pressure. Foreign proteid therapy may be given the same day. The first dressing need not be done before forty-eight hours have elapsed. Daily dressings thereafter will permit irrigation of the cul-de-sac and the instillation of further atropine. If the postoperative progress is uneventful, a monocular dressing will be satisfactory after the sixth day but the pressure dressing should not be discontinued for ten days. As the conjunctival flap slides back, the sutures in the corneo-scleral incision line reappear. These may be taken out as soon as they are wholly uncovered.

While the technique as detailed above has been presented for the cor-

rection of postoperative staphylomata, the same principles apply to the correction of any limbal type of corneal perforation wherein the original healing of the wound or the subsequent repair were unsatisfactory.

TUMORS AND CYSTS OF THE CORNEA

(SEE CHAPTER XXVI)

Neoplasms of the cornea proper are very rare. Parsons states that no case of epithelioma of the uninjured cornea has appeared in the literature. Malignancy at the limbus is somewhat more common. Fibromata, in the form of hypertrophic scars, have been described. Dermoid cysts of the cornea, epithelial plaques and papillomata, sarcomata, endotheliomata, and retention implantation cysts have been seen. The presence of these conditions is usually diagnosed early in their course. In these conditions the likelihood of malignancy, as was stated, is rather uncommon, and superficial cauterization will correct them all. If sarcoma is probable and sufficient tissue is not present for a biopsy, radium therapy should be used. If a biopsy can be done, it ought to be carried out. Sarcomata occur especially at the corneal-conjunctival junction. An important point in the diagnosis of possible malignancy rests with the vascularization of the lesion. Signs of a blood supply to the lesion, apparently separate from the normal blood supply as would be expected, even considering the response to irritation, is diagnostic of malignancy. (See section on Malignancy.)

Epitheliomata are most common at the limbus. Melanotic sarcomata appear next in frequency, carcinomata next, and non-pigmented leukosarcomata are the least common. Gummata also appear in this region, and if possible a differential diagnosis should be made between these and malignancy. Confusion is unlikely in the case of a pigmented sarcoma or of a superficially ulcerated epithelioma. Gummata must always be considered as probable in the presence of positive serology.

The neoplasms themselves appear directly at the limbus and grow as elevated nodular fungus-like masses. Bowman's membrane is shortly destroyed, a gray veil-like corneal infiltration appears, and while the plane surface of the lesion is not especially great, the elevation of the neoplasm is extensive in proportion.

These cases always are a serious problem as to their disposition. One is unwilling to enucleate a seeing eye unnecessarily. At the same time extensive metastases occur in the mediastinum and in the liver, early and late, from these cases. Local surgery oftentimes appears to be successful, but the late results prove otherwise. There is no doubt that removal by desiccation and with a cautery knife followed by radium and by roentgen-ray therapy has resulted in recoveries. On the other hand, immediate enucleations have been followed by late distant metastases. Every case must be considered individually. Epitheliomata and carcinomata can be treated locally with the greatest number of successes. Of the sarcomata, the mixed type of tumor is probably the least malignant. The highly pigmented tumors, especially those arising from melanomata, and spoken of by some as malignant melanomata, are most malignant. The rare non-pigmented leukosarcoma has also a very high degree of malignancy though, probably, this responds best to radium therapy.

The extent and duration of the lesion, the economic status of the patient, his age, and even his family history as to malignancy, are all factors which must be considered in deciding upon the treatment for each case.

CHAPTER XVII

SURGERY OF THE IRIS AND THE ANTERIOR CHAMBER

There are several general points which apply to practically all surgical procedures connected with this structure. Normally, and in health, when the iris is cut, especially with a sharp instrument, a prompt contraction of the iris stroma results because of an incised sphincter with a subsequent unrestrained pull of the dilator fibers. Hæmorrhage, which might otherwise be sharp, for the iris stroma is quite vascular, is promptly staunched by closure of the cut vessels because of this contraction. This is seen in the sharp and continuous hæmorrhage which occurs when operating upon an atrophic or degenerated iris, or upon an iris bound down by synechiæ. Operative procedures on the iris are usually followed by the formation of fibrin in the anterior chamber *even without hæmorrhage. This can absorb* rapidly and wholly. If infection does not occur, nor exudation stimulated when operating upon an iris with an old pathological condition, the incision in the iris will remain open, and recover without the deposition of a cicatrix in the iris. If synechiæ have been present, however, or occur, an original exudate appears and bridges over wholly or in part the coloboma, and results in firm adhesions of the iris to contiguous tissue, either the cornea anteriorly, or the lens capsule posteriorly. Surgery upon the iris is usually done under cocain anesthesia. It may be that the vasoconstricting action of this drug is also a factor in decreasing postoperative hæmorrhage. Certainly the instillation of 1 or 2 drops of adrenalin, prior to surgery, is of assistance in operating upon an acutely or chronically inflamed iris. The action of adrenalin is practically *nil* with a degenerated iris. The iris can be sutured if necessary. A traumatic laceration through the sphincter causes a cosmetic blemish which will remain throughout life, but it would be quite impossible to attempt suturing this. An iridodialysis, however, can be corrected by sutures temporarily buried under a conjunctival flap.

In post-traumatic conditions following perforation of the globe, especially at the limbus, the iris serves as a stop-gap by bridging the lips of the wound. It becomes degenerated and fibrosed and even microscopically would be no longer distinguishable as iris tissue, were it not for the uveal pigment. Under these circumstances, the structure of the iris always changes to some degree, following surgery.

Local anesthetics, by instillation, do not give sufficient anesthesia in a painful eye, nor will they quiet the apprehension of a nervous individual. In some instances a general anesthetic must be used. Retrobulbar anesthesia is at times a necessary adjunct, especially in acute inflammatory conditions, and then it is to be combined with adrenalin. In children, general anesthesia is necessary for these cases cannot be controlled otherwise. Iris surgery which is a part of other procedures, as a cataract extraction or a corneal scleral trephining, in the presence of insufficient anesthesia, is always painful whenever the iris is grasped, pulled upon, or cut. This must be prevented. Iris surgery demands a greater degree of anesthesia than, for instance, conjunctival or corneal surgery.

The armamentarium for iris surgery is extensive. Certain instruments

have inestimable value; others, however, are rather personal and often of interest only to the man who has developed them. A fine delicate iris forceps is an example of the first of these two. This model is satisfactory for practically all forms of iris surgery. With an iridencleisis, however, it is wise to have the curve of the tip of the forceps widened out quite appreciably. So often the pupillary aperture in a case for iridencleisis is smaller than the normal, and one is compelled to reach farther into the anterior chamber through a narrow corneo-scleral incision to grasp the sphincter of the iris. An example of the second of the two statements is seen in the many different types of iris forceps on the market: some are long, others short; some having fenestrated handles, others ribbed handles; some are double-acting and others single-acting. Each operator must select instruments as they feel to him, remembering certain essentials for the instruments, as a class, and learn to use a satisfactory model or type until proficient. The spring-handled, humming-bird bill, iris scissors are very satisfactory instruments for all forms of iridectomy *ab externo*. They are, however, of no value for an iridotomy or for any iridectomy *ab interno*. De Wecker scissors must be used for this, and this can be obtained with double blunt points, double sharp, or with points sharp and blunt. Barraquer's modification of de Wecker scissors, even finer and more delicate scissors, is quite ideal for the intra-ocularly performed peripheral iridotomy of a cataract extraction. On the other hand, they are too small for a broad iridectomy or even in many optical iridectomies, and certainly are of no value for an iridocapsulotomy. Keratomes can be purchased in all sizes and with as many different angles, between the blade and the handle, as it is possible to make. The type of operation to be done and the depth of the anterior chamber in an eye to be operated are the deciding points relative to the shape, the size, and the angle of the blade. A small corneal paracentesis can be done with a wide keratome, if none other is available, but it is certainly not the ideal instrument. The same applies to the narrow limbal incision necessary for an iridencleisis. For this, the ideal keratome is one with an obtuse angle and a narrow blade. A broader keratome may be used if none other is available, but greater care and attention are demanded in making the incision.

Many surgeons prefer a blepharostat. Others operate equally well when the lids are held open by the finger tips of the surgeon or an assistant. Lid elevators of various models can be obtained, and while most are good, the smallest and most delicate lid elevator which can be used is probably the best.

The position of the operator is also an important factor. Naturally, unusual circumstances connected with an operation will be met by a capable surgeon. In most instances, however, surgeons universally use their right hand (if right-handed) for a cutting instrument and the left hand for fixation. The position which will permit greatest visibility is the ideal. Therefore, under all circumstances except those extraordinary ones referred to above, it seems best to have the operator stand to the right side of the patient, facing him, and to introduce the keratome from above with the right hand while the eyeball is fixed at a point on the limbus opposite to that selected for the entrance of the keratome. In this way the various necessary angles through which the handle of the keratome must be carried, in entering the anterior chamber accurately, are readily carried out,

and the surgeon can see the tip of the keratome the instant it appears in the anterior chamber angle. These two points are most important in the technique of an iridectomy, and they demand serious consideration (Figs. 420 and 421).

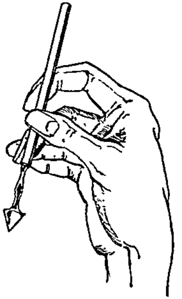


Fig. 420

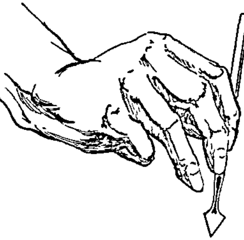


Fig. 421

Fig. 420.—Introduction of keratome from above, facing the patient, and the keratome drawn toward the operator

Fig. 421.—Keratome introduced from above with the operator standing above

The various operations which are to be considered herein are as follows:

1. Iridectomy.
   (a) Preliminary.
   (b) Optical.
   (c) For incarcerated foreign bodies, for cysts of the iris and for tumors of the iris.
   (d) Anti-glaucoma iridectomy.
   (e) Iris prolapse, postoperative and post-traumatic, and the iridectomy of corneal fistulæ, or corneal ectasiæ and of corneal staphylomata.
2. Iridotomy and iridocapsulotomy.
3. Sphincterotomy and sphincterolysis, iritomy and iridolysis.
4. Operative iridodialysis and the repair of iridodialysis.
5. Transfixion of the iris. Chronic relapsing iritis, and anterior and posterior uveitis.
6. The iris surgery of:
   (a) Cataract extraction.
      (1) Complete or incomplete iridectomy.
      (2) Peripheral iridectomy or peripheral iridotomy.
   (b) Corneo-scleral trephining.
   (c) Sclerectomy.
   (d) Iridencleisis.
7. Anterior chamber retention and implantation cysts.

IRIDECTOMY

Iris surgery, as it applies to cataract extractions, to corneo-scleral trephinings, when combined with various forms of sclerectomy, and as a part of iridencleisis, will be considered more in detail under that section which has to do with the major problem under consideration. Iris surgery is an important part of the technique, and with each of these when properly done (under the various conditions which present themselves), the procedure, as applied to the iris itself, may mean the difference between success or failure. There is no doubt that a peripheral iridotomy is ideal in cataract extraction. On the other hand, certain conditions are present at times which demand a complete iridectomy. The same applies to a corneoscleral trephining, though here the indications are even less elastic.

In general, the technique of a simple iridectomy applies to all the conditions for which it is indicated. Those considerations and recommendations outlined in the first part of this chapter are basic, even though many cases have individual characteristics and peculiar demands. General anesthesia must be used in painful eyes, in acute congestive glaucoma, and with children. The keratome is the usual instrument for opening the anterior chamber and, except with a very shallow anterior chamber, the keratome is far better than a cataract knife, regardless of the models recommended for this.

The eyeball is fixed with satisfactory fixation forceps (usually one without a lock) at a point, close to the limbus, opposite to the site for the limbal incision. The tip of the keratome is usually applied about 0.5 to 1 mm. from the corneo-scleral junction line. Many operators will start 2 to 3 mm. behind this, passing the tip of the keratome subconjunctivally to that junction. Undoubtedly many cases of simple, primary non-inflammatory glaucoma, as well as congestive glaucoma, which respond to a simple iridectomy, do so—not because of the iridectomy alone, but because of the long oblique path the keratome takes through the angle of the anterior chamber, reopening thereby Schlemm's canal. For this reason the keratome should enter the angle as far back as is possible. The blade of the keratome, when applied, should be at slightly less than a right angle with the plane of the iris. Figure 422 illustrates this. As soon as the tip appears in the angle, the handle is depressed, as in 2 of Figure 422, so the plane of the blade is parallel to the plane of the iris. The tip is then carried down into the anterior chamber until the width of the incision, at the limbus, is of the proper size. The blade is then withdrawn. When this procedure is started, the anterior chamber may be lost and unless one is careful, the iris itself or even the capsule of the lens will be damaged. To prevent this, the handle of the keratome is depressed even more so, as in 3 of Figure 422, and withdrawn. In this position, if the iris and the lens do move forward, they will not be damaged by the tip of the keratome. As the keratome blade is being withdrawn, it should be moved obliquely sideways against one end of the limbal incision. More aqueous will be retained in this way with an even less probability for traumatizing the lens. The fixation forceps is then turned over to an assistant and the iridectomy itself carried out. The patient is directed to rotate his eye downward (if the iridectomy is being done at 12 o'clock) and to keep it in that position. If the patient is restless or unruly, or if operating under general anesthesia, the assistant will need

to rotate the eye downward with the fixation forceps. He must not, however, press upon the eyeball with the forceps. If visibility is obscured by hæmorrhage into the anterior chamber, this must be washed out first. In irrigating blood from the anterior chamber, it is not always necessary to introduce the tip itself into the chamber. If the irrigator tip is held against the posterior lip of the incision, depressing it very slightly, the fluid will enter the anterior chamber and set up therein a tiny whirlpool carrying out the blood without danger of damage to the lens from a sudden movement of the patient. The iris forceps is then introduced into the lips of the wound, depressing the posterior lip slightly, and the closed tip of the forceps passed downward close to the posterior surface of the cornea until the sphincter iridis has been reached. The blades are then permitted to open for 1 to 2 mm., and a tiny fold of iris is grasped as close to the sphincter as is possible. With the scissors in the operator's opposite hand, held at the lips of the wound, this fold of iris is withdrawn the proper distance and cut off deliberately and smoothly but immediately. If the forceps is not applied at the sphincter margin a tiny bridge of iris may remain uncut. The size of the iridectomy desired is controlled by the amount of iris with-

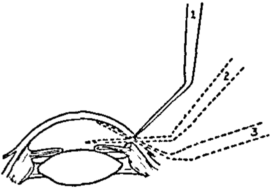


FIG. 422.—Maneuvers with the keratome.

drawn; by the position of the blades of the iris scissors; and by cutting the iris in three stages, as recommended for the iridectomy of glaucoma. Figure 423, *A*, *B*, and *C*, illustrate the grasping and withdrawal of the iris. Figure 424 shows the blades of the iris in a line with the position of the iris forceps for a minimal iridectomy; and *B* with the blades of the scissors at the right angle to the direction of the iris forceps when a larger iridectomy is desired. For an anti-glaucoma iridectomy, first one angle of the prolapse iris is cut, then with continued traction a very slight iridodialysis is done and the opposite angle of the withdrawn iris cut, completing the iridectomy. With the first of the three, as in *A* of Figure 424, it is possible to make an iridectomy so small that only the sphincter itself is resected. With Figure 424, *B* the broadest possible iridectomy can be done and one be certain that the root of the iris has been cut or torn from its base. It is possible that this may open the filtering angle of the anterior chamber. A hæmorrhage, however, rather often develops which must be irrigated from the anterior chamber.

Kirby has shown repeatedly that the size and shape of an iridectomy is modified to a great extent as well by the distance at which one grasps the

iris from the circulus minor. The closer the iris is grasped to the pupillary border the wider the iridectomy and the more converging are the pillars the coloboma. An iris which is grasped mid-way between the root and the pupillary border will permit a narrow iridectomy, with almost parallel

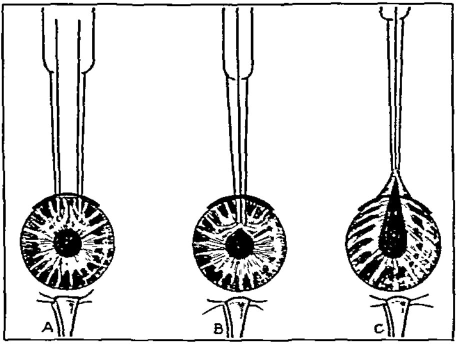


FIG. 423.—Maneuvers with the iridectomy forceps. (Terrien, courtesy of Masson et Cie, Paris.)

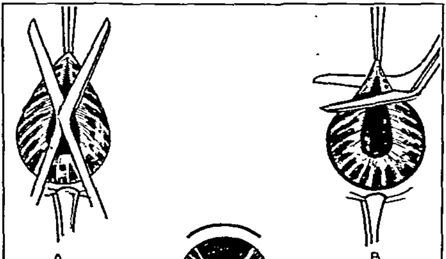


FIG. 424.—Completing the iridectomy. (Terrien, courtesy of Masson et Cie, Paris.)

pillars and with an equal amount of resection at the roots of the iris, as compared with any other type of iridectomy. This finding is therefore to be considered with the technique which includes the position of the cutting blades of the iridectomy scissors.

The reposition of the pillars is of next importance. Irrigation, if this must be done, will often replace the pillars at the same time, so that they now lie normally. They should appear, in general, as in the diagrammatic sketch of *C*, of Figure 424. The iris spatula should first depress the posterior lip of the wound and then be passed into the anterior chamber at the angle so that the back of the spatula lies upon the surface of the iris near a pillar. The iris is then gently stroked toward the coloboma until that pillar or cut edge of the iris lies free. The same procedure is done to the opposite pillar of the coloboma (Fig. 425). Occasionally the iris may prolapse immediately after the keratome is withdrawn, probably because of the abrupt loss of the anterior chamber from a sudden evacuation of the aqueous. An attempt is to be made to reduce this before the iridectomy with the iris spatula. If this is impossible the prolapsed iris will have to be further withdrawn and the iridectomy completed. Because of the prolapse, the iridectomy may be larger than that originally desired, and also it may be irregular. Ordinarily, atropine is instilled into the eye and a postoperative dressing then applied.

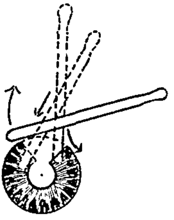


Fig. 425 —Maneuvers with the iris spatula (After Török and Grout)

Various complications and mishaps may arise during the operation. The patient may be so uncontrollable or the anterior chamber so shallow, that an incision of proper size could not be obtained. In such instances the wound must be enlarged by sharp scissors; one tip of these is introduced into the anterior chamber, the other one being external and the wound enlarged to a proper size with short snips of the scissors.

A narrow von Graefe knife often can be used to great advantage in making the incision for an iridectomy in those cases wherein the anterior chamber is absolutely lost. The knife should not be too flexible, but a very fine narrow-bladed knife does seem to find its way more readily between the iris and the posterior surface of the cornea. The incision can be quite small. Passing of the cataract knife for an iridectomy is no different than for cataract surgery. The points at which it should be introduced and the position of puncture and counterpuncture are discussed in the section on cataract surgery.

If the iridectomy has been done subconjunctivally, and it is necessary to enlarge the wound, a conjunctival flap must be completed first. Regardless of the depth of the anterior chamber or of the behavior of the patient, a keratome must be used for an iriectomy in all positions except those close to 12 o'clock and to 6 o'clock on the limbus. If the iris is not grasped close to the sphincter, an uncut bridge of iris may remain intact. It will not happen if the iris is not cut before the dark posterior surface (pars retinæ) of the iris can be seen on the V of the iris tissue within the grasp of the forceps. With posterior synechiæ it is oftentimes impossible to move the

sphincter iridis; further, in such instances, the synechiæ may be so extensive that optical results from the iridectomy are *nil* and the entire coloboma may fill with iris pigment adhering to the anterior capsule of the lens. In these cases, if the sphincter iridis is torn loose from the lens capsule, a traumatic cataract may result. In the presence of synechiæ (regardless of these indications) an iridectomy may compel a later lens extraction, though fortunately this is rare. Occasionally, an iridectomy with synechiæ, because of a weakened zonula from disease, plus the traction upon the lens while doing the iridectomy, will cause a dislocation of the lens. If so, it is probably wise to enlarge the corneo-scleral incision immediately and to proceed forthwith with the cataract extraction. (See section on Cataract Surgery.) With a degenerated iris a satisfactory iridectomy is most difficult to obtain, and this also may compel a later lens extraction. Hæmorrhage in the anterior chamber should be removed by irrigation if it is possible, and especially so in the presence of a diseased iris. Weeks and even months may elapse before absorption of this blood pigment occurs even if blood staining of the cornea does not develop. Prolapse of the vitreous may occur if the zonula is ruptured. A diseased zonula is not uncommon in iridocyclitis, and if the lens has been dislocated, this will almost certainly occur. An unruly patient may be responsible for this unfortunate complication. Iridectomy, in postoperative iris prolapse, with postoperative corneo-scleral ectasia, or with a marginal staphyloma is commonly complicated by vitreous prolapse. For this reason it is wise to operate such cases under general anesthesia.

A few less common complications occur; in general, they are the fault of the operator, though if the patient fails to coöperate on the operating table, this also is a factor. An oblique incision will be made if the handle of the keratome is permitted to turn, so that the blade passes into the anterior chamber, partly through the cornea and partly through the sclera. An interlammelar incision will occur, in the cornea, if the tip of the keratome is not permitted to penetrate the anterior chamber before the handle is depressed, bringing the plane of the blade parallel to the plane of the iris. This complication will be recognized by the non-escape of aqueous and by a peculiar dull gray appearance to the tip of the keratome. As Török and Grout say,[1] part of the blade which appears in the anterior chamber has the same luster as the rest of the blade that has not entered the cornea; the part of the blade engaged in the corneal wound is a peculiar dull gray, lusterless in appearance, and in a properly made incision, this part is but little wider than the thickness of the cornea itself. In an interlamellar incision itself, the engaged part of the keratome is much wider. In exaggerated cases of this error it is possible that the keratome may separate the layers of the cornea without entering the anterior chamber at all. Injury to the iris by the keratome is serious, for the underlying lens capsule may be injured at the same time without the operator being aware of this. The damage may occur when the keratome is being introduced and when it is being withdrawn. A keratome tip which becomes engaged or entangled in the iris while it is being introduced must be immediately withdrawn. The incision must then be enlarged or completed with scissors. For this reason, one dare not continue with the keratome if hæmorrhage should appear and cover the tip of the keratome. Damage to the lens capsule as the keratome

[1] Surgery of the Eye, Lea & Febiger, 1925.

is being withdrawn is seen on the lens capsule as it shows between the pillars of the coloboma. The tip of the keratome will drag across the lens capsule in withdrawing it, if the handle of the keratome is not further depressed. As the iris is picked up with an iris forceps, another opportunity occurs for damaging the lens capsule. A restless patient and poor illumination may be responsible for these instances. It occurs when the tip of the iris forceps is advanced too far across the anterior chamber, that is, beyond the sphincter iridis. Iridodialysis occasionally occurs when the tip of the keratome becomes engaged in the iris, and as the keratome is advanced even farther into the anterior chamber, the iris is torn free from its base.

In general, the postoperative reaction which develops is directly proportionate to the preoperative state of health present in the iris and the amount of damage one has done to the iris with the forceps, the scissors, and the iris spatula. Surgery in the presence of a degenerated and adherent iris, as in old iridocyclitis, should be followed by foreign proteid therapy.

A discussion of the specific indications for a simple iridectomy is quite relevant here. A preliminary iridectomy was at one time considered almost an essential. Various arguments were advanced as an excuse or the reasons for doing it. Perhaps the only logical one was that it did hasten artificially the maturation of an immature cataract. Certainly it permitted artificial ripening if it did not, of itself, do this. Other common statements are that it permits the operator to learn how his patient will behave during an operation, and that it simplifies the subsequent cataract extraction. Both are based upon a fallacy. It actually subjects the patient to an unnecessary operation, it does not simplify the subsequent cataract extraction, and it does make impossible the extraction of the lens with an intact sphincter iridis. In many cases of central nuclear involvement, a preliminary iridectomy may function as a satisfactory optical iridectomy. Many of these cases are poor operative risks for cataract extraction, though they will stand uneventfully the minor surgery of an iridectomy. The progress of the nuclear form of cataract is oftentimes so slow that the preliminary iridectomy may be sufficient to give them fair vision for the remaining years of their lives. Under such circumstances, it is a logical surgical procedure and should be carried out. In general, however, a routine iridectomy preliminary to cataract extraction as a first stage operation is unnecessary and obsolete.

Occasionally, one meets a case of more or less intumescent cataract with secondary hypertension. In these instances, as long as one can satisfy himself that the ocular hypertension seen is not a preliminary form of glaucoma, but is secondary to the lens condition, then a preliminary iridectomy is indicated. It would be unwise to proceed with the lens extraction immediately. Such an iridectomy should be basal in character, *i. e.*, the root of the iris is to be resected at the time of the iridectomy. Equally important, and especially so in these cases, is the great care that the operator must take to prevent operative injury to such lenses. Undoubtedly cataract extractions have been done in the presence of moderate degrees of secondary ocular hypertension without any resulting catastrophe; but it is an improper procedure and is to be condemned. (See discussion under *The Surgical Indications for Glaucoma.*)

Optical Iridectomy.—All other things being equal an optical iridecto[illegible] ...ke, need not be any larger than the individual circumstances peculiar to [illegible]

case demand. For central corneal and lens opacities, its best position is the inferior nasal quadrant. Other circumstances may make it necessary to place it at almost any other point on the limbus. The results of an optical iridectomy are often disappointing. A non-use amblyopia may be already established. Corneal opacities may be accompanied by so much irregular corneal astigmatism that the vision will be improved to a very slight degree. This is one reason why, if done for this purpose, it is to be as small as is consistent with the opacities present in the cornea. Ordinarily an optical iridectomy need not extend to the root of the iris. Naturally, one which lies beneath the upper lid will be of little value. An optical iridectomy done in later years for congenital lens opacities is rather likely to be a disappointment, for these cases are accompanied by amblyopia and nystagmus. Preoperatively one can oftentimes estimate the possible value of an optical iridectomy (regardless of the indications) by dilating the pupil and then studying the visual acuity of the patient through a stenopaic disk or pin-point diaphragm, adjusting this to various positions until one has discovered that which gives maximum vision. Ocasionally, one has no choice in the matter for cases present themselves where the entire cornea is badly scarred except for a small segment at the periphery quite close to the limbus. Even these can be assisted materially. A very small keratome incision is to be made and the iris grasped with a forceps at that point where the artificial pupil is wanted. The blades of de Wecker scissors are then passed into the anterior chamber beneath the iris forceps and that portion of the iris in the grasp of the forceps cut. In this way a round or oval peripheral eccentric pupil will be formed, and even if the sphincter iridis should be adherent behind the corneal cicatrix, one has obtained the best result possible. An iridectomy at the absolute root of the iris, that is, immediately beneath the corneal limbus, is the least satisfactory of all artificial pupils. The physical defects of light which passes through this area of cornea and the underlying lens are great and insurmountable, and do not give any great improvement in visual acuity.

An iridectomy for incarcerated foreign bodies, for cysts of the iris, and for tumors of the iris is grossly no different from any other form of iridectomy. Naturally no more iris should be removed than is necessary to remove a foreign body. On the other hand, while tumors and cysts are usually small, sufficient iris should be removed so that it is reasonably certain one has made his section into and through normal iris tissue. In such tumors of the iris, the patient must be kept under observation, for the eye is always a potential site for recurrences. It stands to reason that microscopic analysis should be made of the tissue removed in all such instances. The indications and the counter-indications for an anti-glaucoma iridectomy will be considered under Glaucoma.

In review, the following points should be emphasized. A subconjunctival approach is permissible and, while not necessary, it does make certain a rather long incision through the depths of the filtering angle. If so, the angle is probably opened by the incision and certainly the root of the iris can be more readily reached in the iridectomy. The width of the iridectomy need not be extensive. The depth of it, however, should go to the base of the iris, even to the practice of cutting first one angle of the prolapsed iris, then doing a small iridodialysis, and the subsequent incision of the opposite angle. The success which follows an iridectomy in acute congestive glau-

coma depends probably upon the evacuation of the contents of the anterior chamber and the relief of tension thereby, and upon opening of the filtration angle of the anterior chamber. It is very doubtful if any "cicatrix a filtration"[1] is formed. Successful results are not uncommon, and the most careful examination of these fails to show any point where subconjunctival filtration is occurring. (See recapitulation of the late results of glaucoma surgery.) It is for this reason that a simple iridectomy is so generally unreliable. In simple non-inflammatory glaucoma, the filtering angle has long since been permanently and irrecoverably occluded, and unless the sclerotomy incision of the iridectomy should happen to reopen it, no successful results can occur. Subconjunctival filtration must be established in such instances.

The use of a mydriatic following an iridectomy for glaucoma is to be decided in each individual case; for certainly one does not wish to have postoperative synechiæ develop. An initial immediate postoperative instillation is proper while the anterior chamber is still open and remaining unformed. After the anterior chamber has reformed, synechiæ can be prevented by the use of the adrenalin dilators alternated with the various miotics.

The iridectomy of postoperative and post-traumatic prolapse, that of corneal fistulæ and that of ectasiæ and of limbal staphylomata have been discussed in part under the section on surgery of the cornea. The iridectomy for prolapse after a cataract operation will be covered in that section. The optical iridectomy of congenital dislocation of a lens is also considered in that subsection. (See the Marfan Syndrome.) A conjunctival flap is necessary in almost all of these instances. After the iridectomy, the pillars of the iris coloboma must be free. Corneal or scleral sutures at the limbus may be used whenever they are necessary. The conjunctival flap can be moved down above them, and they themselves may be taken out after the flap has returned to its original site. In all of these cases the flap should be prepared and the conjunctival sutures in place, though untied, before the anterior chamber is opened, the iridectomy done, and the juxtacorneal bridging of conjunctiva or of cicatrix resected. In operating an iris prolapse, Leber felt that it was advisable if possible to release the iris from the lips of the wound through which the prolapse occurred. If was his recommendation that the overlying conjunctiva be opened, the iris prolapse grasped in a forceps, and blunt probe passed around the entire circumference of the prolapse releasing it from its adhesions before the prolapse itself is resected. After a prolapse, irrigation of the anterior chamber and the careful use of the iris spatula, will permit freeing of the pillars of the coloboma so that a satisfactory result can be obtained.

Attention is to be called to Vogt's[2] composite iridectomy, which is a diagnostic iridectomy in the presence of an immobile iris, and of aphakia when it becomes necessary to search the vitreous chamber in detail, and the contracted iris would make this difficult; also in cases wherein possible loss of vitreous (aphakia) would be serious. After subconjunctival injection of novocain, from 3 to 5 tiny openings are made at the extreme margin of the cornea with a small lance knife, each opening being from 1 to $1\frac{1}{2}$ mm. long.

[1] Terrien, F., Chirurgie de L'Oeil et de ses annexes, Masson et Editeurs, 1921.

[2] Vogt, Die operative Therapie und die Pathogenese der Netzhautablösung Verlag Enke, Stuttgart, 1936.

These openings are made parallel to the root of the iris by a very rapid entrance of the knife and as rapid a withdrawal so that no aqueous is lost. He then uses his very small forceps (Vogt's Scherenpinzette), introducing it into each one of these tiny openings, withdrawing as much of the iris as is possible and resecting it with pince-sciseaux. As the 3 to 6 holes which he has made at the limbus are all grouped close together, these multiple partial iridectomies form one large coloboma without the loss of any aqueous or vitreous, a composite iridectomy wholly satisfactory for any subsequent investigation or surgery.

Iris Prolapse.—Bettman and Barkan[1] are very much in favor of the use of trichloracetic acid in the treatment of iris prolapse. They feel that the advantages of trichloracetic acid over the actual cautery (see section on Limbal Surgery, page 566) are important. Quoting them:

> The advantages of trichloracetic acid over the actual cautery are several: (1) the acid produces a dry, white coagulum which prevents the entrance of bacteria; whereas the cautery causes sloughs and burns tissue and therefore actually favors the multiplication of bacteria. Moreover, this coagulum is formed immediately, and is therefore a guide to its application. (2) A firmer cicatrix results and there is therefore less danger of a resulting staphyloma when trichloracetic is used. (3) The acid can be applied more evenly over a large prolapse. (4) There is less reaction following its use than when the actual cautery is applied. Trichloracetic acid (CCl_3CO_2H) is obtained in crystalline form, and in this form is exceedingly hygroscopic The method of using it is as follows: The eye is thoroughly cocainized. A few of the crystals are put into a medicine glass and 1 drop of saline is added. It is essential that only 1 drop be added in order that a saturated solution may be obtained The crystals go into solution quickly and absorbed sufficient water from the air to dissolve completely. A toothpick is dipped into the solution. The wood absorbs enough acid for the purpose and any excess is carefully wiped off on the edge of the medicine glass. The region of the iris prolapse is dried with a cotton applicator The point of the applicator containing the acid is gently touched to all parts of the prolapsed iris or, if the iris is under the conjunctiva to the conjunctiva over it. Almost immediately the prolapse will be seen to turn a milky-white color. After a few minutes (the eye held open during this time) the eye is irrigated well with saline to wash out the remaining acid. The above procedure is repeated daily for about a week, and then about twice weekly. After a week's application the prolapse diminishes in size, flattens remarkably, and begins to be covered with a thin white eschar.

Naturally the total period of treatment varies with each individual case, but when used in properly selected cases it produces results which cannot be equalled by other methods of treatment, and the author, with them, believes it deserves a more general consideration. Its danger lies in the fact that, while it may remove the extruded iris, it does not release the incarcerated lips of the iris. Hence, it has the same contraindication as that for the use of the actual cautery; not to be used in the presence of iris irritation, not indicated in major prolapses, and its use must be carefully checked by repeated slit lamp examination, an iridectomy to be done instead of the acid if any posterior punctate keratitis is present, and its use stopped if any posterior corneal deposits develop.

There are some contraindications to iridectomy, and while they are few in number, they are no less important because of this. The "pros" and "cons" of a preliminary iridectomy have been discussed. An optical iridectomy is unnecessary unless one is able to improve vision. Dilating the

[1] Am Jour Ophth., Ser. 3, vol 20, February, 1937.

pupil and examining the visual acuity with a pin-hole diaphragm and/or a stenopaic slit will decide this. Extensive staphylomata with secondary glaucoma are usually hopeless conditions, and an enucleation is more often indicated in these than is iris or corneal surgery. In chronic secondary or post-iritic glaucoma an iridectomy or some similar form of iris surgery is indicated. In the acute phase of this, however, an iridectomy is not indicated unless mydriatics have been of no avail in breaking down the iris synechiæ, and the case continues progressively worse in spite of the usual therapeutic measures instituted with repeated corneal paracenteses. (See Section on Secondary Glaucoma relative to this.) An iridectomy is often without results in severe iridocyclitis without ocular hypertension, but with an inflamed and abnormally vascular iris with ocular hypertension; its use is frequently of great benefit though fraught with danger because of

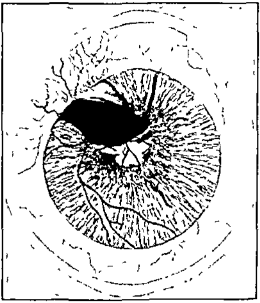


FIG. 426.—Extensive vascularization of a degenerated iris.

subsequent rapid lens changes. This may occur even though the lens has not been injured by the surgery. (One sees a similar sequence of events not uncommonly after a basal iridectomy for acute congestive glaucoma.) The cause of this probably rests with nutritional impairment of the lens. Injury to the lens during such an iridectomy is a most unfortunate occurrence. It always results in further iridocyclitis and demands further surgery. In such instances one must be prepared to do a lens extraction subsequently or perhaps very shortly thereafter. It is wise from a medical-legal standpoint to inform the patient of this possibility.

Cases occasionally present themselves where there seems to be indications for an iridectomy or iridocapsulotomy. The iris is, however, highly vascularized, with large tortuous venous loops (Fig. 426). At the same time the iris stroma shows considerable degeneration. In such instances a patient is rather likely better off without further iris surgery.

IRIDOTOMY AND IRIDOCAPSULOTOMY

These are procedures for conditions seen following cataract extractions, traumatisms, and other inter-ocular operations. They have, as their aim, an incision through the iris, or the iris and an opaque capsule, reëstablishing thereby a clear pupillary aperture. The procedures will be discussed in the section on the complications following cataract surgery.

SPHINCTEROTOMY AND SPHINCTEROLYSIS

They are the operations indicated in the presence of anterior synechiæ, *i. e.*, when the iris has become adherent to the posterior surface of the cornea. Sphincterotomy and sphincterolysis have been discussed in part in the section on Surgery of the Cornea, Chapter XVI. The most important points are repeated here. Adequate illumination and operating binocular loupes should be used, regardless of the age of the operator or the state of his accommodation. In most instances, especially in those cases wherein the synechiæ are not purely central to the cornea, the pupil should be contracted with a miotic before the instillation anesthesia is used. Sphincterolysis is the operation of releasing an adherent sphincter iridis from the posterior surface of the cornea. It is done usually with a fine Ziegler knife needle. The point of entrance, through the cornea near the limbus, is ordinarily on the same horizontal meridian at the external limbus as are the anterior synechiæ. The fibers can be cut in part with the cutting edge of the knife and also, in part, released, using the back of the knife as a curet. Sphincterolysis, according to Schulek, is for the larger and more dense anterior synechiæ, especially when they are eccentric. In these cases the pupil must be contracted. The eyeball is fixed with proper forceps and a narrow cataract knife or a Wheeler knife needle passed through the cornea at the limbus near to the adherent synechiæ. The tip is passed across the anterior chamber above the scar, and then to a counter-puncture on the outer side of the scar, that is, the knife (in the case of an inferior leukoma adherens) would be passed from 7 o'clock on the limbus across the anterior chamber for its counter-puncture to 5 o'clock. Schulek, in his original operation, made the puncture and the counter-puncture always in the cornea. The operation now is done commonly from limbus to limbus, as recommended by Blaskovics. As soon as the counter-puncture has been made, the synechiæ are cut by a to-and-fro movement of the knife. It can be withdrawn without completing a corneo-scleral section as soon as this has occurred. Occasionally a leukoma adherens is accompanied by a small corneal ectasia. In such instances Schulek's technique may be used. A Wheeler knife needle is passed through the cornea at the edge of the scar, with its counter-puncture on the opposite side of the scar. The adhesion is severed the same way, with the cutting edge of the knife, down to the limbus; but a bridge of conjunctiva is allowed to remain intact there so that the corneal flap formed by the knife is held in position. The iris will retract as soon as the synechiæ are cut, for the operation should be done under pilocarpin or eserin miosis, and a satisfactory pupil ought to appear above the point of puncture and counter-puncture.

The operation known as iritomy, according to de Wecker, is rather similar, except that the synechiæ are cut with a keratome, and a peripheral

iridectomy is performed on that portion of the iris external (juxtalimbal) to the cut in the sectioned adhesions. De Wecker's scissors should be used for this. If the lens is normal and in position during this operation, care must be taken that the anterior capsule is not further damaged during the iridectomy. Also the keratome should be withdrawn as carefully as possible, as in all keratome incisions.

Iridolysis was an operation first advanced by Lang for releasing iris synechiæ by means of two knife needles, a sharp and a blunt one. It has no advantages over the three other procedures mentioned, and the difficulty of doing it and the dangers connected with it more than offset any value it may have. The iridectomy (iridotomy) of de Wecker, of Czermak, the Ziegler V-shaped iridotomy, and several satisfactory or slightly more complicated forms of iridotomies, will be considered in the section connected with *after-cataracts.*

Anterior synechiæ are not uncommonly connected with traumatic cataract. One is faced here with the problem of which condition should be corrected first. The loss of the anterior chamber after a keratome incision makes further surgery upon the anterior synechiæ practically impossible at that time. In most instances, in an operation for a traumatic cataract, the keratome is the proper instrument for opening the anterior chamber. The operator usually cannot correct the synechiæ and do a linear extraction at the same time. In a case of synechiæ lying close to the limbus, it might be possible to use a cataract knife to section the synechiæ as described under sphincterolysis, and then complete the corneal section and proceed with the lens extraction. Such corneo-scleral incisions must be kept quite small, limbal puncture and a counter-puncture are usually necessary for the satisfactory sectioning of synechiæ, and in all cases, except most unusual ones, this should be the guiding rule. For that reason it is sometimes wise to sever the anterior synechiæ first and then at a later time remove the *traumatic cataract. The same applies to iris prolapse with extensive lacerations* of the cornea. At the time of the initial repair the iris prolapse must be resected but, if the eyeball is to be saved, it is better to work for satisfactory healing of the initial corneal damage and then to sever, at some later time, the anterior synechiæ which may remain. It would be unwise to attempt complete release of the adherent iris from the posterior surface of the cornea at the time of the first operation, and by extensive and too long continued surgery damage the lens or even jeopardize the integrity of *the eyeball. Many corneal lacerations are V-, X-, or T-shaped. Even* when covered with a conjunctival flap (as they should be when originally repaired) the anterior chamber is so slow in reforming, due to the shape and extent of the wound, that even if a complete release of an incarcerated and prolapsed iris is obtained, subsequent synechiæ develop postoperatively.

In general, if it is possible, anterior synechiæ are best corrected with a knife needle. The keratome and the cataract knife when withdrawn leave a collapsed anterior chamber and new synechiæ may, as a result, immediately *reform. The withdrawal of a knife needle, however, does not result* in the loss of the anterior chamber, and this complication is thereby prevented.

The movements which the operator should impart to the knife needle are somewhat different from those used with the cataract knife. Beard[1]

[1] Augenarztlichen Operationem Czermak-Elschnig, vol 2.

speaks of these former as being "slicing in nature," dividing the adhesions as the knife is withdrawn. When using the knife needle, its point of insertion in the cornea, or at the limbus, acts as a fulcrum, and elevating or depressing the handle as the case may be, applies the edge of the knife firmly against the fibers of the synechiæ. This renders them even more taut than that tension obtained by the miosis alone. Lax fibers cannot be cut with a knife needle, no matter how sharp it may be. The movements of a cataract knife or a Wheeler knife needle are essentially a sawing, to-and-fro, movement and there is no utilization of a fulcrum for cutting a synechia with these. After these operations, maximum dilation of the pupil should be obtained, by atropinization, and postoperative hot compresses started as soon as possible to minimize postoperative inflammation. Foreign proteid therapy is also usually indicated.

IRIDODIALYSIS

Operative iridodialysis is a procedure deliberately carried out in certain operations connected with the treatment of glaucoma. The broad iridectomy to be discussed for simple non-inflammatory glaucoma is probably successful only because of the coincident iridodialysis, unless it should be that incarcerated iris pigment causes the filtering cicatrix. Certain operations which incarcerate the iris subconjunctivally, with the formation of a filtering bleb, also have as part of their technique an iridodialysis. The author, in working on the iris inclusion operation in the eye of the rabbit,[1] had included this technique in some of his rabbit operations. One of the statements made therein in the conclusion of the original article is as follows, "There is a doubt whether iridodialysis, though it simplifies the amount of incarceration, plays any important rôle in the permanent results. It does make possible an early eversion of the iris, but the immediate hæmorrhage that occurs is an unwanted complication."

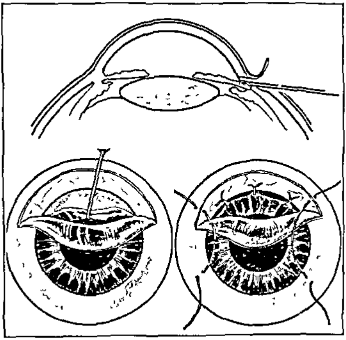
Traumatic iridodialysis is not uncommon. Unilateral diplopia may be present, a late secondary glaucoma is not uncommon, and the cosmetic defect is oftentimes marked. The dialysis may be of all degrees, varying from that of a minute and barely visible separation to one so complete that the iris is contracted to a small gray bundle still adherent to the limbus at only one place. A case with this degree of involvement is not surgical except for the consideration of corneal tattooing, as long as they do not develop a secondary glaucoma. The lesser forms of iridodialysis, even if multiple, can be satisfactorily corrected surgically. Several men have written about it, showing fairly consistent results. No operative procedure should be attempted until the eye has recovered wholly from the effects of the original trauma. Naturally this means that any hyphemia from the original defect must have absorbed entirely.

Cocain anesthesia is instilled, but the pupil should be kept in moderate contraction with pilocarpin A van Lint type of conjunctival flap is to be lifted from about the limbus and the smallest possible keratome incision then made through the sclera, 1 mm. behind the termination of the cornea. A sharp Tyrell hook is introduced through this incision into the anterior chamber, on its flat, laid upon the iris as close as is possible to the detached root, the hook engaged in the iris stroma, and withdrawn a very slight

[1] Arch Ophth., 8, 550–567, October, 1932.

amount (Fig. 427, *A*). While it is held in this position, a fine No. 6-0 enameled black silk suture is passed from the anterior surface of the iris through its structure, and the hook released. In the case of Figure 427, *B*, three such sutures were passed, giving the immediate appearance seen. The needle is passed with a very small bite in the sclera at the posterior lip of the keratome wound, the suture tied firmly and the ends cut short. The tip of a very narrow iris spatula can enter each of these incisions and smooth the iris to the lips of the incision, assisting in the incarceration. A small iridodialysis can be corrected, usually with one limbal incarceration; a larger separation will need several. The conjunctival flap is then brought over and sutured.

A



B *C*

Fig. 427.—The technique of iridodialysis correction.

These multiple incarcerations might function as filtering cicatrices, but this is not desired. Therefore, five days later, the conjunctival sutures are to be untied, the flap allowed to retract to its original position, and the iris incarceration sutures removed. Each one of these incarceration points is then carefully but lightly wiped with the actual cautery, destroying the bit of iris tissue which was extra-ocular and at the same time cauterizing the superficial layers of the sclera there. The flat conjunctival sutures are then again tied, or replaced, for two further days, after which time they can be cut and removed permanently. Six months after the operation one is unable to tell that the patient had had an iridodialysis without examination with a slit lamp. Glaucoma has not appeared in any of these repaired cases.

Key,[1] in operating upon 2 cases of extensive iridodialysis, did practically the same operation, except that his sutures were not buried; instead they

[1] Arch. Ophth., Ser. 2, vol. 15, May, 1932.

were made to pass out through a very small conjunctival flap hinged at the cornea and not arranged according to van Lint's technique. The sutures through the iris were tied upon the conjunctival surface and the lips of the wound, for the flap above it, sutured in addition. Considering the possibility of infection from these exposed sutures into the iris it seems wiser to bury them temporarily under the conjunctival flap than to allow them to be exposed upon the conjunctival surface. Jameson, in 1909,[1] advocated placing the sutures in such a way that the iridodialysis was not incarcerated, but the torn edge of the iris was caused to impinge against the posterior surface of the cornea near the original attachment. Wheeler[2] feels that iridodialysis should not be operated unless there is some good reason for it, and that if this reason is present a very simple procedure will suffice. At the site of the iris opening, a keratome incision is made through the limbus and the attachment permanently secured by simply carrying a tiny shred of tissue from the torn edge of the iris very slightly into the limbus wound. Wheeler assures us that it is effective and offers the least possible immediate or late danger.

TRANSFIXION OF THE IRIS AND IRIDECTOMY FOR CHRONIC RELAPSING IRITIS AND ANTERIOR AND POSTERIOR UVEITIS

Transfixion of the iris is a procedure first recommended by Fuchs (Ernst) for the "iris bombé" which develops in cases of occlusio et seclusio pupillæ. The procedure is essentially a double iridotomy. If the lens is cataractous, it may be removed at a later date. As secondary glaucoma is usually present, the aqueous, as it lies behind the adherent sphincter iridis and the root of the iris in the posterior chamber, balloons out the iris stroma. The usual iridectomy cannot be done because of the extensive synechiæ and the degenerated iris tissue. Figure 428, *A*, shows the faulty position of the iris with its adhesions in seclusion of the pupil, as the cause for the secondary glaucoma which is present in these cases. Also it illustrates the path of the cataract knife used for the transfixion. The cataract knife enters the cornea no more than 1 mm. from the limbus, is to be passed directly into the iris beneath it, to emerge from the iris near the pupillary aperture, and again to enter the iris near the pupillary margin on the opposite side of the pupil, is then to be continued through the humped iris, and to emerge from the iris, and from the cornea directly above it by counter-puncture at a point near the opposite limbus similar to the point of entrance. The knife is to be withdrawn rather quickly. The anterior chamber collapses, and the iris should recede to a normal flat position with perhaps some slight gaping of one or more of the four incisions which were made in the iris. The ocular hypertension should recede immediately. As soon as the eye is white, the operator may proceed with the cataract extraction if this is necessary. Occasionally a secondary iritis will develop as the result of this operative procedure, and if so, the results of the operation will be nullified by further exudate. In such a case the late results may be even worse than were those present at the time of the initial operation. It is then necessary to attempt a complete iridectomy, being prepared to proceed immediately with the cataract operation in case the lens capsule is opened or dislocation

[1] Arch. Ophth., vol. 38, 1909.
[2] Am. Jour. Ophth., Ser. 3, vol. 17, August, 1934.

of the lens occurs. Chronic recurrent iritis with multiple synechiæ is oftentimes treated quite satisfactorily with an iridectomy at that point on the iris where the major number of synechiæ are present. When the procedure is successful, inflammation recedes, the accompanying descemetitis is improved appreciably, and other additional forms of therapy used seem to respond much better. The result in part may be due to the paracentesis of the anterior chamber. It cannot be denied, however, that release of the adhesions and the resection of a portion of this diseased iris has repeatedly given results clinically which are not wholly coincidental. At times this surgery may also stir up an iritis to such a degree that the iridectomy is again closed, no satisfactory results are obtained through the surgery, and the condition which follows will be even worse than before. This has been observed following an iridectomy for secondary iritic glaucoma. If the operation is to be successful, it must be done during a quiescent interval. After the keratome incision is made, the iris is grasped at its sphincter and the synechiæ torn by firm traction, which is slowly applied. Synechiæ can be torn from the iris without damaging the lens capsule, though damage has occurred to the lens capsule with capable operators and with the best

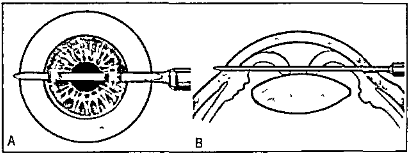


Fig 428.—Transfixation of the iris (Courtesy of P. Blakiston's Son & Co)

of technique. The prolapse of the iris and the iridectomy are completed the same as would be carried out for an uncomplicated preliminary iridectomy. The pillars are to be replaced, and hæmorrhage and débris irrigated from the anterior chamber. Iris stroma, and the sphincter ring of pigment, which remain adherent to the lens, should not be disturbed, no matter how extensive. An attempt to remove them will certainly cause a traumatic cataract. Foreign proteid therapy must be used after the operation. Atropinization is most important at this time. Glaucosan and subconjunctival injections of adrenalin and of atropine are valuable adjuncts, if they are necessary.

A chronic low grade iridocyclitis, without synechiæ with a posterior uveitis, also occasionally responds to a simple iridectomy. Here as well, one wonders whether improvement is not in spite of the iridectomy and because of the drainage of the anterior chamber. There is no wonder that repeated anterior chamber paracenteses have been accepted as a rational treatment in such conditions. The operation is frequently recommended, however, and does seem of value in many instances in which it had been done.

ANTERIOR CHAMBER RETENTION AND IMPLANTATION CYSTS
(SEE CONJUNCTIVAL CYSTS)

These conditions are traumatic or postoperative. Congenital cysts of the iris are quite a different thing and have already been discussed, page 578. The implantation and retention cysts are difficult to treat, and even with the best of treatment they usually result in the loss of an eyeball through secondary glaucoma or because of the surgical procedures attempted for their cure. Their walls are thin, and generally they cannot be grasped and prolapsed, for resection, as one would grasp and prolapse the iris. Evacuation of their contents is followed by their reformation. Wide limbal incisions, made abruptly, will at times result in their partial prolapse with the gush of aqueous which results, but it is hardly sufficient for their satisfactory removal. They become attached to the surface of the iris and an extensive iridectomy might result in a cure. Both diathermy coagulation and electro-cautery coagulation have been attempted without consistent success. Considering these cases, by and large, the only successful results obtained have been in those wherein the cysts could be removed together with an iridectomy. Rankin[1] recently presented from Wills Hospital, Philadelphia, a case of a large primary cyst of the iris, confirmed histopathologically as such, and not a malignancy, wherein a satisfactory cure was obtained following an iridectomy done "ab externo." The case and the successful recovery are both uncommon. (See Plate V.) Following the keratome incision, the iris was permitted to prolapse spontaneously. It was grasped by a portion of normal iris tissue contiguous to the cyst, the iris cut there, then, by continued traction, an iridodialysis performed until normal tissue at the opposite edge of the cyst was presenting to permit a scissor snip there for completion of the iridectomy and the simultaneous removal of the cyst. It may be necessary to repeat the operation if they should occur. Roentgen-ray therapy has been attempted and may be of assistance. Diathermy coagulation offers much more hope for success than does actual electrocoagulation. The prevention of these conditions is their best treatment, if irritation is a factor.

Postoperative epithelial cysts (see section on Cataract Complications) have been treated by Kirby with sclerosing solutions, including a solution of 50 per cent dextrose, and by Vail with a 1 per cent solution of tincture of iodine. In both instances the cyst is evacuated by a syringe and needle being careful not to rupture the cyst wall. Sclerosing fluid or the iodine is injected into the cyst cavity and then withdrawn by the hypodermic needle. The walls of the cyst thus collapse.

Magitot, in his analysis of iris cysts,[2] speaks of four types, quoting Lagrange's classification: simple cysts, pearly cysts, dermoid cysts, and cysts caused by parasites. Simple cysts, either traumatic epithelium implantation cysts or idiopathic, have quite dissimilar courses, the former continue to a very severe degree of involvement by reason of the lawless growth of the implanted epithelium—the latter are almost self-limiting in their course. Histologically, (Magitot) "gives no support to the hypothesis of a graft of epithelium," they possess an epithelial wall, have multiple

[1] Personal communication.
[2] Trans. Amer. Ophthal. Soc., 20, 301, 1922.

PLATE V

Cyst of the iris, spontaneous, non-malignant.

(Courtesy of Dr Charles Rankin)

diverticulæ, a normal amount of connective tissue structure, have a normal amount of blood supply, and have as contents "a liquid similar to aqueous." This is the type of cyst reported by Rankin.

The pearl cyst is rather likely a connective tissue mesodermal developmental defect, not epithelial, nor lined with epithelium, with very poor circulatory supply, and cystic only by reason of central degeneration—as compared to the possibility of the simple cyst contents as present if not by actual formation of this aqueous—then by dialysis of fluid through the walls of the numerous small vessels. The other two types of cyst (Lagrange's classification) are self-descriptive.

Because delayed healing of wounds of the cornea is responsible for a certain number of these cysts, they should be treated so that the epithelium will not be permitted to grow into the anterior chamber. The development of an implantation cyst following a cataract operation can usually be prevented by satisfactory and adequate toilet of the operative wound. Postoperative fistulization from a spreading incision line was responsible for one case seen. Cilia in the anterior chamber should be removed even with an iridectomy. Other similar foreign bodies have been responsible in individual instances.

CHAPTER XVIII

ETIOLOGY AND DIFFERENTIAL DIAGNOSIS OF CATARACT. GENERAL CONSIDERATIONS CONNECTED WITH CATARACT SURGERY

CONSIDERATIONS AND INVESTIGATIONS NECESSARY FOR CATARACT SURGERY

The surgery of cataract, in the final analysis, is a much more simple problem than is that of glaucoma. This applies certainly to the indications. The manual dexterity necessary for the surgery of the two conditions differs but little. With the average cataract operation the postoperative care is also a relative simple procedure. With the complicated cases, however, the postoperative care necessary is far more important than the surgery itself. There is no doubt that improper postoperative care can ruin completely a beautiful lens extraction, but it is equally true that intelligent and careful postoperative care can save much vision following a wretched surgical operation. Poor surgery is not always the fault of the operator, even though many of the immediate complications which arise can be prevented.

A cataract operation, when done under local anesthesia, depends to a great degree upon the full coöperation of the patient; it is no wonder that many of the recent advances in surgical therapy are planned to combat these various possibilities. The preoperative sedatives, the newer anesthetics, the various forms of blepharostats which appear, the size and the shape of cataract knives, the great number of capsule forceps which appear in the surgical instrument catalogues, and even the discussion of intracapsular extraction as compared with capsulotomy extractions, all have this—the coöperation of the patient well in the foreground. That single point of investigating the case with which the patient's pupil can be dilated, euphthalmine or homatropin, prior to the operation, may be the deciding factor between failure and success.

The time at which cataract surgery is to be done has undergone a rather marked change in recent years. Formerly the unfortunate patient was compelled to spend years, often with poor vision to no vision (except for light perception), waiting for the cortex to become mature. If intracapsular surgery had no other point in its favor, this one is worth the technique alone; that is the ability to operate successfully in immature cataracts without subjecting the patient to all the various postoperative complications which can and do arise as a result of retained cortex. In general, the time to operate is at that time when the patient becomes incapacitated for his work, or for his comfort by reason of the impaired vision. If this dictum is followed, one can imagine the necessity for operating in an individual of a certain profession or of a certain disposition, with the vision impaired only to 6/12; on the other hand, other patients might continue with fair comfort and with but little impairment of their capacity with a visual acuity reduced to 6/45 and less.

Cataract surgery in the very aged is quite a problem. Each instance

must be carefully investigated as a separate individual and not arbitrarily considered "too old" or "too infirm to operate." Many patients at the age of eighty years are physically better for surgery than others at the age of sixty years. The probable years of postoperative life should be estimated as closely as is possible, without resorting to clairvoyancy. Nevertheless, a patient of advanced years is to be handled with great care. If one can minimize, in the patients' mind, the seriousness of the operation, they may consider the surgery a matter of only temporary discomfort and of brief hospitalization, and by assuring them of early reading vision, a vision which they had before the onset of the cataract, then a state of mind will be achieved certain to minimize shock and its effects. A quiet unobtrusive procedure of the necessary preoperative investigation will also help. With aged and delicate patients, no harm should arise in getting them out of bed on the second day after a satisfactory lens extraction with a well-sutured corneo-scleral incision line.

Cataract extraction in the insane and the epileptic usually demands general anesthesia.

Naturally, the blood-pressure should be controlled and the patient's strength maintained by proper nourishment. The necessary caloric content can be given with fluids and semifluids in small amounts every two hours to accomplish this and still save the patient from gastric distress and flatulence. The physical condition of a patient is the criterion of operability, and not the age of the individual.

A unilateral cataract should be operated when it approaches maturity, even though the patient's opposite eye is normal. It is unnecessary to permit a patient to continue with visual acuity cut to light projection, in one eye, simply because the visual acuity in the other eye holds at 6/6 It is not only unnecessary, but also it may be dangerous. The patient's field of vision on that side is definitely restricted, and even though the postoperative aphakia cannot be glassed, still the patient has satisfactory protective form and motion perception, following lens extraction. In permitting the retention of such a lens, there is a constant possibility of an inter-current secondary glaucoma. Clinic patients demonstrate this unnecessary complication so often that no one can deny the factor.

The slit lamp microscopy of an involved lens is outstanding in importance when one is considering surgery. The age of the patient, his occupation, and other etiological factors as traumatisms, diabetes and parathyroid deficiency, preëxisting uveitis, preëxisting diagnosed and undiagnosed retinal separation, drugs as dinitrophenol, and the changes of senility, are relevant to that which one should see with the slit lamp. More specifically, a dinitrophenol cataract can be of such a varying degree as to range from its bare presence to cortical liquefaction, so marked that the lens capsule is simply a retaining envelope for fluid contents in which the brown and freely movable nucleus has gravitated to the bottom of the sac. Certainly, the surgery for these two phases of the same condition should be quite dissimilar and could only be so decided by careful slit lamp microscopy.

PREOPERATIVE INVESTIGATIONS FOR CATARACT SURGERY

As soon as the opinion has been reached that surgery is necessary in any case, regardless of the indications or the type of cataract present, certain studies are necessary even before the patient is admitted to the hospital.

These have been covered in part in Chapter I, but they should be reconsidered here.

The condition of the conjunctiva, of the lacrimal sac, of the nose, the patient's dental condition, and the hygienic condition of his mouth in general, are all most important. The author feels that cultures are quite necessary as a part of this investigation. A slight infestation with the Bacillus xerosis or with a non-hemolytic Staphylococcus albus are ordinarily not contraindications to surgery. A gross infestation, however, with these and the presence of any pyogenic organisms is a contraindication, and remains so until the cul-de-sac can be cleared of them. This is not always a simple procedure. Lacrimal sac irrigations will assist, though if a culture is taken immediately after such irrigations the subsequent bacteriological report will be most disconcerting. Weak solutions of silver nitrate, 1 to 10,000 aqueous metaphen irrigations, and even the use of bichloride ointment in a 1 to 3000 strength is at times necessary. The author uses routinely an ointment of collargol made up of 1 part of liquid petrolatum, 2 to 4 parts of white petroleum jelly (depending upon the season of the year), and 5 parts of the collargol. It is the procedure recommended by Lindner for sterilizing the cul-de-sac. The cul-de-sac is irrigated, filled with this ointment and the lids closed with an occlusive dressing. This is applied, in the same manner, twice a day. Each morning before the ointment is reapplied and after the irrigation of the cul-de-sac with normal saline, a culture is taken. As soon as the report is bacteriologically satisfactory the case is ready for operation, but the occlusive dressing and the collargol are continued daily until the operation.

Intra-ocular surgery cannot be done in the presence of an infected tear sac. The tear sac should be routinely irrigated to be sure of the patency of the lacrimal-nasal duct; the presence of epiphora should put the surgeon immediately upon his guard. The mucocele of an obstructive dacryocystitis must be treated properly before the intra-ocular surgery is carried out. Oral sepsis also is a contraindication and muct be cleaned up before any surgery is attempted.

Visual acuity is to be recorded, with and without the ametropic correction. The fields of vision must be studied and if the acuity of vision is too low for the usual technique, with large test objects, then one must investigate the field by studying the light projection. In this examination the patient fixes upon the illumination of a small electric ophthalmoscope bulb, while a second of the same degree intensity of illumination is moved in from the periphery, as in any test object. This is the only way in which one can obtain an idea as to the state of health of the optic nerve and the retina in those cases wherein the fundus cannot be seen. Even central scotomata of small degrees can be diagnosed in this manner. The patient will describe a dark spot in the central field of the diffuse illumination derived from the small and slightly dimmed ophthalmoscope light used for central fixation.

The ability or failure to identify the illumination from two luminous ophthalmoscopes, bulbs simultaneously exposed, as "two lights," as they are brought together and separated, one from the other, is another satisfactory means of determining the condition of the macula, the retina, and the optic nerve, in a lens opacification so dense that even light projection is not conclusively satisfactory.

Friedman[1] and Eber[2] separately described an original test for this examination. Friedman's is as follows:

One removes the head from the electric ophthalmoscope and places the light, covered by the condensing lens of the instrument, against the closed eye. Pressure is made against the sclera, and the light gently moved to and fro. The vascular tree will appear as a black tracery against the reddish background. The macular area is clearly defined as a dull red, avascular oval. The patient is told to look for a pattern similar to the veins in a leaf. With this simple simile even unintelligent patients are surprisingly quick to recognize the vessels. The good eye, in unilateral cases, is examined first as a control, and the patient is told to pay particular attention to the vessel-free area. He is then asked to compare it to the corresponding region in the cataractous eye. The response is more difficult to elicit and less reliable when there is no obviously healthy eye to serve as a control. A patch of central chorioretinitis will be seen as a spot where the patient sees nothing in the red field, and the surgeon is thus forewarned. An amblyopic eye in which a cataract has developed, unless it has a squint to draw suspicion, might easily become another pitfall, but in such a case the patient will see his macula as a black or dark brown spot, and will again forewarn the operator. Retinal detachments may be readily detected by subjective visualization, and most likely this method will prove of value in instances of retinal detachment in which the projection of light is not faulty. Like all subjective tests, it depends greatly on the accurate coöperation of the patient. The examiner should previously practice the test on himself, and learn to take into account in the evaluation of results the effects of retinal fatigue and the brightness of the light.

The ocular tension should be within the normal limits. If the eye is hypotensive, one may expect fluid vitreous and a cataracta complicata of long standing from a preëxisting cyclitis or uveitis. If the eye is hypertensive a different and more complex problem is present. The ocular hypertension may be primary, and not connected with the lens swelling, or it may be secondary and due to the lens changes. The history of the case, the degree of the visual acuity, the condition of the iris, the state of the fields of vision, and even the tension as present in the fellow eye are all salient factors and of assistance. If it is decided that the first of the two is the situation in the case under investigation, then trephining is indicated, and the lens extraction should be done later. If, however, the ophthalmologist feels that the glaucoma is secondary to the lens changes, then the cataract itself must be removed after a preliminary iridectomy has been done. The interval between the two operations needs to be only sufficiently long to permit the eye to recover from the first stage of the operation, but this recovery must occur before the extraction is carried out.

The mobility of the iris, its response to mydriatics, the presence of synechiæ, and the depth of the anterior chamber, are all important factors. The state of the iris will often modify the surgery, in that an atrophic iris must be handled differently from a healthy iris, the same as one must handle a spastic sphincter quite differently from one which is normal in mobility.

The diagnosis of the type of cataract itself should be clearly and definitely made: *i. e.*, congenital and the type; traumatic and the duration of the cataract changes from the trauma; for the differentiation of a congenital cataract from a traumatic cataract is often difficult and this question is frequently present in both these possibilities; a cataracta complicata in a young person cannot be handled similarly to the same type of cataract in

[1] Arch Ophth., vol 5, April, 1931.
[2] Am Jour. Ophth , 5, 973, December, 1922.

an adult, or in one of senile or presenile age; the cataracts of dinitrophenol poisoning and of parathyroid deficiency need special attention; a nuclear cataract without cortical changes and a nuclear cataract with cortical changes cannot always be handled similarly; a hypermature lens, especially those with extensive cortex liquefaction, is a definite separate entity; and industrial cataracts as the cataract of glass blowers and the cataract of electrical shocks and of exposure to unusual degrees of heat, cannot always be diagnosed from the history alone. The Vossius ring cataracts which result from deposition of blood on the anterior capsule as Zentmayer[1] and Woerdemann[2] demonstrated must be handled as a complicata.

The patient's general physical condition must be carefully investigated. This includes his blood sugar and occasionally his blood urea. Standardization of a patient's blood sugar in diabetes is an absolute essential before cataract surgery can be done. Not only is preoperative standardization necessary, but one must also insist on the medical man maintaining postoperative standardization as well.

This is even more important in the postoperative treatment of the case. It is far better if the blood sugar can be controlled through diet alone for the first few postoperative days. The diet demands, in caloric amounts as well as the various carbohydrates, proteids, and fats necessary, can be subdivided into 4 to 6 portions and those given to the patient at more frequent intervals during the day rather than at the usual three times a day meal hours. If the zinc protamine insulin is not being used, then the older form of insulin should also be subdivided into fractional doses to allow for better blood sugar control. In general, the total amount of insulin used for the first three postoperative days should be reduced to as low an amount as the patient's condition will permit for that length of time.

The hæmorrhagic complications which arise postoperatively, and which result from failures to accomplish this standardization can be the cause of a complete ultimate failure for the surgery. It seems that postoperative control by diet, rather than by insulin, begets fewer complications. The urine analysis and a determination of the kidney function is essential, especially in the aged and in those in otherwise poor health. Blood calcium determination and calcium standardization by parathyroid injections are necessary in those cases where parathyroid pathology is the etiological factor.

The blood-pressure and the condition of the patient's myocardium and the condition of his peripheral vascular circulation are of great importance. Surgery cannot be done successfully in the presence of vascular hypertension, though of the two a well compensated hypertension is far less serious in its consequences, than arteriosclerosis with hypotension and with myocarditis. In Lindner's clinic[3] in patients with a blood-pressure of 180–200, an ampule of 0.04 per cent papaverin is given intravenously one-half hour before the operation. If the blood-pressure is above this, venesection is done, removing from 300 to 400 cc. of blood. Naturally, this should be performed, and the blood withdrawn, quite slowly. Hypostatic pneumonia, myocardial failures, cerebral apoplexy, and postoperative

[1] Am. Jour. Ophth., 7, 676, July, 1924.
[2] Nederl. Tijdschr. v. Geneesk., 67, 862, 1923.
[3] Klin. Monatsbl. f. Augenh., 103, 156–169, August, 1939.

expulsive subchoroidal hæmorrhages are all connected with these conditions. The patient's response to medication, especially to sedatives, must be determined and known, because an intelligent use of these also may be the deciding factor between a failure and a success in surgery.

In cases of bilateral cataract the two eyes should not be operated at the same time under any circumstances. This procedure has been advocated by eminent men at times, and upon casual consideration it has some strong arguments. The dangers, however, are entirely too marked. The possibility of infection is one, and in spite of all precautions this does occur. An expulsive hæmorrhage may occur in one or both eyes. Postoperative iritis may develop, sympathetic ophthalmia has occurred, and any one of the other various immediate and late complications can develop. If the postoperative course has been uneventful the second eye may be operated seven to fourteen days after the first, but even in such instances, special care is necessary so that the patient will not damage the first of the two eyes operated by undue squeezing. Further, a routine investigation of the first of the two eyes operated may impair the later operation by insisting that the "patient look down."

If the surgery cannot be done in a hospital where the surgeon is familiar with the surroundings and where assistants and nurses are well acquainted with his postoperative technique, then the surgeon must be certain that every possible contigency has been covered, in so far as the postoperative treatment is concerned, before he leaves the patient after the operation. The patient should understand thoroughly which of the two eyes is being operated upon to safeguard the operator from possible postoperative law suits. In the case of bilateral cataract it is not always wise to operate on the eye which has a cataract of longer duration, naturally considering in such instances a probability that the patient will be able to have only one eye operated upon. In some institutions, the surgery is done with the patient on a wheel litter, in others in the bed. These operative beds have removable head boards and are on wheels so that they can be moved in and out of the operating room readily. Both of these practices have points in their favor. For routine purposes, the latter of the two procedures is perhaps the better. Certainly, the aged and cataracts with high myopia should be operated in the bed if it is possible.

The preoperative preparation of the patient should start the day and *the night before the operation. This implies admission forty-eight hours* in advance. This period will permit the completion of investigations not already done and also will permit the patient to become a bit accustomed to the new surroundings. If arterial hypertension is present, a longer period of preoperative hospitalization will be necessary. Arterial hypertension can be reduced a marked degree by proper rest in bed and by the preoperative medication of bromides, the barbiturates, sodium nitrite, by light diet and by mild saline catharsis. One should not make a hard and fast limit for systolic and diastolic pressure tension as to the limits for surgery. (This same applies to the amount of the fasting blood sugar.) In general, however, a blood sugar above 150 mg. per 100 cc. and a blood-pressure with a systolic above 170 mm. of mercury with a normal proportionate diastolic (that is, certainly no higher than 90 to 100 mm. of mercury) are fair working limits. If the blood-pressure cannot be reduced below this with reasonable medication, a phlebotomy may be done a short

time before the surgery. This must be done slowly, however, and be controlled by the sphygmomanometer. Its effects are only transient, and they can be dangerous. Medication should be used so that the patient has a satisfactory night's sleep before the operation. Morphine and even codein tend to nausea and are constipating: not only does this advice apply preoperatively, but even more so postoperatively. It is well to establish this dictum as one of the general preoperative rules, *i. e.*, morphine and codein are not to be given unless specifically ordered by the surgeon himself. Occasions may arise where they must be used, but these are extraordinary and not routine.

SURGICAL PRINCIPLES OF A CATARACT EXTRACTION

The surgical principles of a cataract extraction are founded firmly upon an anatomical basis, and are so certainly interrelated with this basis, that serious complications develop if these are not taken into consideration; for instance:

1. The complete absorption of lens fragments which result from the discission of a congenital cataract done in the early years of life is possible only because of the histology of the lens at this period of life. On the other hand, a dense calcified plaque present at the same time on the posterior capsule of the lens will not undergo absorption and must be removed in its entirety.

2. The satisfactory results which follow the linear extraction of a traumatic cataract are only possible if this surgery is done at the proper time, that is, when the lens itself, both the nucleus and the cortex, are fragmented and infiltrated with the watery aqueous.

3. An intra-capsular lens extraction is possible in the later years of life only because of the senile zonula. On the other hand, persistence in attempting an intra-capsular lens extraction in a patient of younger years and with a firmer zonula may result in a low-grade cyclitis and in the subsequent development of vitreous opacities to a most distressing degree.

4. The expression of a lens, especially with an intra-capsular technique, is made possible only because of the basic dynamics of fluids within a contained body. Within the corneo-scleral shell, the incision line being the weakest point, the pressure within the contained space drives the diaphragm of the lens and its suspensory ligament forward toward this opening. The direct trauma to the suspensory ligament applied below with a hook, ruptures the zonula there. The lens, therefore, can only move forward at its free lower pole with its upper pole hinged, acting, however, at the same time as a cork to restrain the vitreous from presenting in front of it, for if this would occur the effects of the pressure applied to the scleral shell would be nullified and further motility of the lens would cease. These principles apply regardless of the use of a capsule forceps at the same time to rupture the zonula.

5. The possibility of intra-capsular extraction is the means of saving a patient from a long wait of years with impaired vision, an interval formerly necessary for the development of liquefaction of the cortex, that is, maturing of the cataract. The dangers of retained cortex and of capsule remnants are not to be minimized. Ophthalmitis phaco-anaphylacto-genica is a definitely established serious clinical entity. Secondary glaucoma, from

the retention of these substances, and an iritis precipitated and continued undoubtedly by cortex, means a long convalescence, subsequent surgery, and often in the end, poor visual results. Even an adequate incision for the lens extraction is based upon anatomical grounds. Many men have made, in various languages, a most pertinent statement to the effect that "incision is the most important part of the operation." It is a tragedy to attempt the extraction of a large and almost globular lens through an incision so small that it is physically impossible for the lens to pass through that incision.

In discussing the surgery of cataract extraction there are six general procedures to be considered, each a definite entity with specific indications: (1) Primary discission of the lens. (2) Linear extraction. (3) Capsulotomy extraction with complete iridectomy. (4) Capsulotomy extraction without complete iridectomy but with peripheral iridotomy. (5) Intra-capsular lens extraction with complete iridectomy. (6) Intra-capsular lens extraction without complete iridectomy but with peripheral iridotomy. With some of these, the indications are rather hard and fast; with others, somewhat less so. The tables on pages 602 and 603 show in general the indications for each of them. In considering discissions, at this time, the author is not including post-cataract operative discissions wherein the matter of retained cortex remnants and capsule are the factors. Primary traumatisms to the lens with lens swelling and with capsule damage, but without prior surgery to the lens, are to be considered under linear extractions rather than under discissions, though the trauma was, in effect, a discission.

SURGICAL PATHOLOGY OF CATARACT

For convenience, though in effect it is correct, cataracts of all types may be grouped into seven general classifications: (1) congenital cataracts; (2) traumatic cataracts; (3) the cataract of parathyroid affections, of dinitrophenol, glass blower's cataract, thermic and electric cataracts, and the lens of high myopia; (4) cataracta complicata (complicating cataract); (5) presenile and senile nuclear and cortical cataracts. Duke-Elder[1] feels that senile cataract appears more frequently and at an earlier age in the presence of diabetes and also he has described a rarer form characteristic of and peculiar to diabetes wherein a rather rapid liquefaction of the cortex occurs due to a decrease in the osmotic pressure of the aqueous because of the rising sugar concentration in the blood with diabetes, provided the available water reserve is maintained; (6) Morgagnian cataracts, regardless of whether it is a hypermature cataract of parathyroid pathology, of dinitrophenol or of senile origin; and (7) dislocated lenses.

1. **Congenital Cataracts.**—There is but little cortex present in congenital cataracts early in life, and the nucleus when incised can undergo complete absorption. The procedure is safe, and it can be repeated if absorption ceases due probably to sealing of the wounds in the capsule. Opaque flakes and plaques, however, will not absorb and may need a keratome incision capsulotomy, or even a de Wecker scissors discission. The vitreous should not be incised during a discission for congenital cat-

[1] Text Book of Ophthalmology, London, Henry Kimpton, 1, 815, 1932, Pathologic Action of Light Upon the Eye, Part 2, Action Upon the Lens in Theory of the Genesis of Cataract, Lancet, i, 210, 1188–1191, 1250–1255, 1926.

aract. The lens swollen masses may occasionally be responsible for a transient period of ocular hypertension, demanding corneal paracentesis. The patient must be operated upon as early as possible to prevent mental retardation in the patient.

2. **Traumatic Cataract.**—Traumatic cataract is almost always the result of a perforating wound of the lens. Because of this, the condition is essentially a soft, immature, fragmented cortex and nucleus, the same as one following an intentional discission. Some of these cases, especially in the very young, may go on to a spontaneous absorption of all lens remnants. In the older patients especially, progressive generalized opacification develops but without further absorption. Traumatic cataract develops from a blow to the eye, in some cases even without perforation of the eyeball. In these the opacification of the lens develops more slowly.

Daudry[1] quotes Trelat as follows, "Beware of traumatic cataracts; they accompany traumatisms in all their variety and are frequently associated with all their consequences. It is the half-successes and the failures which make up the balance sheet of the operative treatment of traumatic cataract. In general every injury to the crystalline lens should be considered as a serious menace to an eye." This quotation describes only too well the vagaries which follow the treatment of this condition. Apparently the time for the surgical extirpation is of secondary importance as compared to the degree of traumatic iriodocyclitis present, hypo- or hyper-tension, absorption from traumatized lens cortex, accompanying cyclitis (especially when hæmorrhagic), and the presence of intra-lenticular foreign bodies.

Traumatic cataract has been reported from insect stings, and from the penetration of the eye by the cysticercus; the cataract of a retained fragment of copper is quite characteristic; in some instances concussion or contusion cataracts, without perforation of the eyeball are accompanied by a Vossius ring. This, which probably consists of fibrin crystals, usually disappears in four to six weeks. The lens opacification itself may remain stationary or may go on to complete opacification.

Surgical operations to the eye may result in a traumatic cataract, as glaucoma, and may modify the case to a great extent. Such cases may need a linear extraction but it is more likely that a capsulotomy extraction will be necessary. The surgery of traumatic cataract consists of a keratome incision, the opening of the capsule with the keratome or with a capsule forceps, and the subsequent expression of the lens fragments by massage upon the cornea with a hook, while the corneo-scleral incision line is held open by a spoon or a loop. Irrigation of the anterior chamber with a warm normal saline solution must be continued until all loose lens fragments have been removed. In general, an iridectomy is not necessary in these cases unless the iris continues to prolapse. In certain cases, a tiny peripheral iridectomy will correct this, in others, a complete iridectomy may be necessary. Old, shrunken, and sclerosed traumatic cataracts, some with and some without synechiæ, usually can be removed through a keratome incision and with a capsule forceps, as the Kalt, the Arruga, the Elschnig, the Verhoeff, or even, if necessary, a toothed capsule forceps. Firm synechiæ may demand an iridectomy, but in many cases the lens remnants can be detached if a satisfactory grasp can be obtained with a capsule forceps. Clinical observations of various forms of traumatic cataract have revealed

[1] Trans. Ophth. Soc. United Kingdom, vol. 42, 1942.

many interesting and unusual circumstances. Outstanding is the fact that perforation cataracts frequently do not go on to complete opacification. In many of them stellate opacities appear and remain stationary for years. For this reason, cases of traumatic cataract which might come within this possibility should be observed a bit before extraction is carried out. Naturally in many of these cases the lens is so badly damaged that the proper therapeutic interventions are clear cut and definite; in others, however, the preceding statement should be remembered.

3. **Cataracts of High Myopia, Tetany, Etc.**—High myopia has a definite surgical indication in that lens extraction will reduce the refractive error by that amount present in aphakia. The surgical indications are not clear cut, however, and the demands for an operation when present in any one case must be sharply outlined. Lens extraction is not a cure for progressive myopia, and many cases of high myopia have such a huge peripapillary retinal staphyloma that the macula itself is involved. Improvement in vision cannot be expected in such instances. If lens changes are already present, then the case must be considered under a discussion of complicata or of immature presenile cortical cataract. A preliminary discission is to be followed by a later linear extraction, especially in those of early life before the age of forty years. The vitreous should not be incised during the discission. The discission itself ought to be a bit more extensive in its capsulotomy than that done for congenital cataract The postoperative observation must be close, however, in that a secondary glaucoma may develop from the rapid swelling of the lens and herniation of lens fragments into the anterior chamber. The eye should be quiet, if possible, before the linear extraction is done, two to three weeks being the usual interval after the discission. An allergic iritis and iridocyclitis will occasionally develop demanding lens protein desensitization. Such a condition develops before the linear extraction can be done. It is essential in these cases that the pupil be kept widely dilated because in many instances a mild postoperative iritis develops. Meller, in discussing the indications for the surgery of high myopia, mentions not only the state of the fundus but also insists that the degree of myopia must be more than 16 diopters in that the difference in the refraction produced by the removal of the lens, amounts to somewhat more than this; that the patient's other eye should still be useful; that is, it must not have suffered separation of the retina or a severe choroiditic process; and *that the operation is limited to patients under forty years of* age. Separation of the retina follows rather frequently after myopia lens extraction. This same complication is not present to the same degree of frequency in operating myopes for complicata and for presenile and senile, nuclear and cortical, cataracts. The cataracts of parathyroid infection, of dinitrophenol, glass blower's cataract, and thermic and electric cataracts are occasionally rather rapid in their development and continue to an early complete liquefaction of the cortex. Instances are not uncommon in these cases wherein the lens will be changed to a bag of fluid, with a brown crenated nucleus lying at the bottom of the sac. At least one such instance was seen where it was felt that if surgery could have been postponed, the entire lens would have gone on to spontaneous absorption. A careful slit lamp examination is necessary, so that the operator can decide whether a linear extraction will be sufficient, or whether it will be necessary to do the usual capsulotomy extraction. In the cataract of postoperative tetany

(*i. e.*, tetany which results from interference with the function of the parathyroid glands due usually to the removal of the parathyroids during thyroidectomy) O'Brien[1] felt the postoperative prognosis should be definitely guarded due to the high incidence of delayed spontaneous hæmorrhages after lens extraction. It is quite important that before and after the lens extraction of such cataracts, the patient receive parathyroid hormone, viosterol, and a high calcium intake. In some of these cases it is proper to attempt extraction by an intra-capsular lens extraction. This applies especially to the cataracts of parathyroid deficiency. In all of these different types, the older the patient, the greater the possibility of achieving this. If the capsule does rupture the operator can always proceed to the usual capsulotomy extraction. In some, the capsule has been ruptured, as in cases of glass blower's cataract and in such a capsulotomy extraction will be necessary. A complete iridectomy need not be done unless the iris continues to prolapse during the operation, or if the lens cannot be delivered through the pupil present. A peripheral iridotomy may correct the iris prolapse but a complete iridectomy will be necessary if the pupil cannot be opened or if it contracts following the corneo-scleral incision. A peripheral iridotomy should be done if a complete iridectomy is not necessary. It will prevent iris prolapse and incarceration of the pupil, both of which are rather common after a simple extraction. The writer prefers to do the peripheral iridectomy before the lens extraction, though many operators do it after the lens extraction.

4. **Cataracta Complicata.**—Cataracta complicata or complicated cataract is due to a preëxisting uveitis or to some similar intra-ocular pathologic state. Tuberculous iridocyclitis, especially in the earlier years of life, chorioretinitis, tuberculous and non-tuberculous; severe and long continued iridocyclitis from any cause whatsoever; heterochromia iridis; glaucoma; retinitis pigmentosa; separation of the retina; contusio bulbi; high myopia, especially when accompanied by great changes in the vitreous; intra-ocular hæmorrhages, traumatic and non-traumatic; and dislocation of the lens have all been described, and quite properly so, as the cause of this form of cataract. Undoubtedly, other causes are also responsible. Low grade chronic intoxications and chronic foci of infections have almost certainly been responsible in some instances, though perhaps in these cases the accompanying iridocyclitis was either not found or it had recovered spontaneously before the cataract changes developed. Cases of cerulean cataract and some of the rare forms of cataract may also develop upon a complicating basis. Some long-standing chronic illnesses seem to be followed by cataract of this type. Cataracts with post-thyroidectomy tetany and myotonia dystrophy, and other dysfunctions of the other endocrine glands have been seen in their early stages, and in some of them the onset was very much like that of the ordinary complicata. If these cases are seen before a complete opacification has occurred, it is much easier to place them into a proper category, that is, to know that they are forms of complicata. Characteristic changes are still present, however, even late in the development of this type of lens pathology.

Meesmann[2] described a cataracta complicata as beginning at and about

[1] Arch Ophth., vol. 7, January, 1932.

[2] Die Mikroskopie des lebenden Auges an der Gullstrandschen Spaltlampe Atlas typischer Befunde, Berlin, Urban & Schwarzenberg, 1927.

the posterior pole of the lens. The first changes are rather definite disturbances in the color of the posterior lens shagreen. Somewhat later, changes appear in the subcapsular zone at that region. Some of these are not only plaque-like but also project anterior-ward in the posterior cortex. All sorts of designs may appear, rosettes, rings, and foliate figures. The color is of a yellowish tint, and this may progress to such a degree and extent that it seems as if one were looking into a brass bowl. At times a peculiar porous limestone-like appearance is present, in others the opacity looks cloud-like. These changes have indistinct margins and fade off very gradually into the surrounding normal cortex. Small droplets appear, and at times cholesterine crystals can be seen. The normal anatomic markings of the lens are slowly lost. The opacities on the posterior capsule widen out more and more approaching the equator of the lens involving progressively the adult and the embryonal nuclei. At this time the picture is quite characteristic and pathognomonic of a complicata. Later on in the course of the condition, disturbances continue through the lens into the anterior axial capsule. The changes here resemble in part those which have occurred in the posterior cortex and subcapsular zones, lying not only subcapsularly but also in the capsule. That appearance of porous limestone is seen here as well as in the posterior portion of the lens, also the color changes in the lens shagreen.

The surgery of the complicata is rather complex. The tables on pages 604 and 605 show that practically each form of surgical technique plays a part in the treatment of complicata. Visual acuity is impaired very early in these cases, and if the condition happens to be bilateral, early surgical intervention is necessary. In the complicata of childhood and of early adult life a discission may be necessary, this to be followed by subsequent linear extraction. In general, however, the surgery of early complicata is that of a capsulotomy extraction either with or without an iridectomy. A wide capsulotomy may save the patient from a subsequent discission. The pathology of the condition itself, however, results in a high percentage of necessary discissions later on, especially if the case must be operated while in an immature stage. So many of these cases have had an iridocyclitis or a posterior uveitis as the basic factor that it is not uncommon, following surgery (and even when the eye was presumably quiet and showed no chronic inflammatory changes), to have an iridocyclitis reoccur with the many possible complications which can result from that situation. The complicating cataract is still the *bete noir* of cataract surgery. A case in the later years of life should be operated by the intra-capsular method if it is at all possible. The intra-capsular lens extraction obtained through the use of an erisophake is here one of the outstanding reasons for using this technique. Even at the best, the surgery of a complicata is occasionally disappointing, in that all the cases must be operated while the cortex is still quite immature.

5. Senile Cataract.—Peripheral Iridectomy. Preliminary Iridectomy.—The surgery of presenile and senile nuclear and cortical cataracts falls wholly within the realm of either capsulotomy or intra-capsular lens extraction. The older the patient the more possible is an intra-capsular extraction. Furthermore, those lenses which are hypermature need this form of extraction to save the patient the postoperative irritation which so often develops following an unwanted rupture of the capsule. It is true that cases

which the cortical involvement has progressed to extensive liquefaction will give as good visual results following a capsulotomy extraction with a wide capsulotomy by toothed forceps as one would obtain through intracapsular extraction, and without the necessity of a later discission. The black cataracts of high nuclear involvement should also be extracted intracapsularly if possible because of retained sticky cortex which cannot be irrigated from the eye and which may demand subsequent discission if not removed. The prevention of possible vitreous prolapse and the danger of subretinal hæmorrhage following this suggests the advisability of capsulotomy extraction in the very aged.

A complete iridectomy had best be done at the same time in such cases to facilitate the extraction and to prevent later possible complications. An extraction with a round pupil and with a peripheral iridectomy is beautiful in its visual results, it is comforting to the patient in that glare is seldom present and it does give a pretty cosmetic appearance to the eye. (See section, Iridectomy, page 572.) The incidence of postoperative iris prolapse is more common when a complete iridectomy is not done because it was apparently unnecessary. The threshold which lies between the necessity for a complete iridectomy on one hand and the permission or advisability of an intact sphincter on the other is wide and often intangible. This matter of rigid pupil was discussed in detail by Wright[1] in his recent lectures on cataract. Relative to the small and rigid pupil, Wright stated that much greater care must be exercised in cataract extraction with a small pupil no matter what method is used.

Many would say that the easiest way of getting over this difficulty is invariably to perform a complete iridectomy; but, as mentioned before, we think it is most important in intracapsular work to retain a round pupil if possible. Even in capsulotomy work the iris certainly plays a useful part in preventing cortical or capsular tags coming forward to the section. Hence the avoidance of the complete iridectomy unless indicated for other reasons. Surgeons have frequently observed that when an intracapsular operation is successfully undertaken in an eye with evidence of old inflammatory trouble, the eye is apt to remain perfectly quiet. For this reason it is often preferable to remove the cataract with limited adhesions by this method; but reasonable care must always be taken not to damage the iris with the drag or to tear the capsule, for it sometimes happens that the capsule, rather than the point of adhesion, gives way with the gentlest movement of the forceps. In fact it is always desirable gently to explore and break down such posterior adhesions first.

In speaking of the peripheral iridectomy, A. Fuchs[2] emphasizes the importance of the anatomical structures which lie immediately posterior to that portion of the sclera where the peripheral iridectomy is located.

If one has excised a piece of iris, there lies behind it, pushed back slightly by the ligament of Zinn, the vitreous with the anterior border layer. This is sometimes solid and sometimes not so solid. In any event, after the extraction of the lens, one should treat every coloboma with care. After an extra-capsular removal of the lens, one can distinguish in the region of the coloboma two parts: the peripheral portion, where the vitreous presses against it, and the more central portion corresponding to the peripheral part of the iris. In the latter portion lies the equator of the capsule of the lens, which forms the ring-shaped Sömmering thickening of the periphery of the capsule after the operation for cataract. This Sömmering thickening explains why in the ordinary operation for the removal of cataract, the iris does not tremble to any extent although the lens is removed. If the lens has been

[1] Am. Jour. Ophth., Pt. 2, Ser. 3, vol. 20, February, 1937.
[2] Arch. Ophth., vol. 16, September, 1936.

removed within the capsule, this fact can be recognized later not only from the absolutely black pupil but also from the very tremulous condition of the iris In the latter case the vitreous humor presses forward more than in the case in which the operation was extra-capsular, and this is probably the reason why later the pupil so often rises upward and the root of the iris is pressed secondarily against the posterior wound of the cornea. It is certain that the tremulous condition of the iris and this instability of the anterior border layer are not without effect on the colloid equilibrium of the vitreous, and detachment of the retina following intra-capsular extraction, an occurrence which is relatively frequent, is perhaps ascribable to this tremulous condition or lack of stability of the iris These details of anatomy of the area of the peripheral coloboma are of special importance for the operator who performs peripheral iridectomy after the Hess method. He finds himself then in the region of Petit's canal, in front of the circumlenticular space If he has produced a small defect in the periphery of the iris he should take care not to make an entrance at this point again with any instrument If he does, it may happen that he will injure the anterior border layer, and then the vitreous will flow off, thereby enlarging greatly the small defect in the iris If he has attempted to excise a small portion from the periphery of the iris but is not certain whether or not he has succeeded, he should take care not to repeat the attempt at the same point; for it might happen that through a small defect not observable through the limbus he will come in contact with the vitreous and will tear out with the iris forceps a portion of the anterior border layer, which will result in loss of vitreous. It is much better to perform a new peripheral iridectomy, more to the nasal or to the temporal side, since for the purposes of peripheral iridectomy it is not important whether the defect is straight above or more to one side, and cosmetically it is not significant since both points are covered by the upper lid If he has made two defects, it does not matter particularly. Occasionally a second defect is made if the iris at any point cannot be reduced and the lack of rotundity of the pupil points to incarceration of the iris. In any event after making a peripheral button-hole iridectomy, it is advisable (in the manner of Professor Meller) to spread out on the finger whatever may have been excised, in order to discover whether really iris tissue or pigment from the excision is sticking to the teeth of the forceps. If iris is not found the excision should be repeated at a point near by, as stated Vitreous may flow through the peripheral defect in the iris likewise spontaneously After removal of the lens and the making of the defect in the periphery of the iris the defect may suddenly become enlarged and vitreous exude through it

Šafář[1] also feels that it is better to make the iris opening before the intracapsular extraction since after the extraction vitreous lies behind the iris and in the pupil and tends to prolapse in subsequent manipulations of the iris. If hæmorrhage occurs into the anterior chamber after the incision or the iridectomy, it must be removed before the extraction. One would be rather unwilling to do this after the lens extraction has occurred.

Kalt[2] when operating with a peripheral iridectomy dilates the pupil preoperatively to a moderate degree with atropine, 1 drop of a 1 per cent solution diluted in 40 drops of water, instilled the night before, and he has abandoned the use of eserin postoperatively, instilling atropine only at the time of the first dressing. There is no doubt in the author's mind that success in operating with a round pupil is proportionate to the degree of trauma to which the iris is subjected. Maintaining its muscle tone is essential, and the extraction of a lens within the capsule through an inadequately dilated pupil is responsible for the greatest amount of trauma to the iris. Further, during an extraction the longer it takes to extract a lens through such a pupil, the greater is the amount of trauma to the iris. The operator must consider each case carefully as individual, and as circum-

[1] Am. Jour. Ophth., Ser. 3, vol. 13, March, 1930.
[2] Ann. d'ocul, Paris, 160, 689, September, 1923.

Cataracta complicata in early adult life as well as in the later years of life			liminary to the lens extraction. An intra-capsular extraction if attempted and unsuccessful will result in a rupture of the capsule and demand a subsequent capsulotomy procedure. Iridectomy is to be planned as a subsequent step, however, and not as a preliminary maneuver unless the pupil cannot be dilated adequately. Post-extraction vitreous prolapse may make an iridectomy imperative.	of some synechia though these can be broken down with a small spatula as a preliminary maneuver following a corneo-scleral incision. The iridectomy is not necessarily a primary step though subsequent immediate complications may make it necessary. These same considerations apply to the cataract of parathyroid involvement also though not wholly similar.	(See immediately above.)
Morgagnian cataract and cataracts which are hypermature.			See complicata. The ideal procedure if an intracapsular is impossible or fails. Iridectomy should be done, however, even as a primary maneuver if postoperatively there is a possibility of iris prolapse. Peripheral iridectomy may prevent that in some instances. Satisfactory [illegible] of the [illegible] of the eye when accompanied by a satisfactory peripheral [illegible] Post-extraction vitreous prolapse may make imperative a post-extraction complete iridectomy. [illegible]	See section on complicata. An iridectomy is indicated as a primary procedure when the iris will not remain replaced, if the pupil cannot be adequately dilated, if synechiae are present which cannot be broken down with a spatula or if the lens extraction is followed by vitreous prolapse. The possibility of probable later postoperative iris prolapse is best combated by an immediate complete iridectomy. An iridectomy is generally indicated in the aged.	The ideal procedure in these instances. An iridectomy should be done only if persistent iris prolapse occurs or when post-extraction vitreous presents, also if dilation of the pupil cannot be achieved for the lens extraction itself.
[illegible] hypermature lenses	[illegible]	[illegible]			If attempted will undoubtedly result in rupture of the capsule and compel a capsulotomy extraction.
[illegible] luxated lens	[illegible]	[illegible]	[illegible]	[illegible]	An ideal procedure and a necessary procedure, especially in instances of recent dislocation, and with normal intraocular tension. [illegible] and vitreous presentation prior to the extraction should be completed with an intracapsular lens extraction as [illegible] as possible.

TABLE OF SURGICAL INDICATIONS

Type of cataract	Type of operation indicated					
	Discission	Linear extraction	Capsulotomy extraction with iridectomy	Capsulotomy without iridectomy but with peripheral iridotomy	Intra capsular extraction with iridectomy	Intra-capsular extraction without iridectomy but with peripheral iridotomy
Congenital cataract	Operation of necessity in practically all cases, even though linear extraction may be necessary thereafter	After discission for congenital cataract linear extraction is indicated in some instances. Repeated discissions are dangerous but a linear extraction cannot be done unless the lens had undergone swelling and fragmentation with liquefaction from contact with the aqueous. If this is not present a discission must be repeated				
Traumatic cataract	Occasionally necessary as a preliminary to later linear extraction. May result in a complete absorption of the lens in patients below the age of thirty-five years	The operation of choice in traumatic cataract but only if the slit-lamp examination shows extensive generalized soft opacification. If this is not present capsulotomy extraction will need subsequent discission	Occasionally an old shrunken lens of earlier traumatic cataracts will need extraction wherein synechiae are so dense that an iridectomy must be done at the same time	The operation of choice in shrunken sclerosed old traumatic cataracts wherein the lens is reduced to a shrunken nucleus and a sclerosed capsule. Multiple synechiae may be broken permitting an intra-capsular extraction in some instances, but in others capsule remnants will remain	See column on capsulotomy without iridectomy, or with peripheral iridotomy	In shrunken sclerosed and old traumatic cataracts an ideal procedure, especially in the young to retain a central round pupil. May demand freeing of synechiae first with iris spatula
High myopia, cataract of parathyroid affections, of dinitrophenol, thermic and electric cataracts	High myopia has a surgical indication in that linear extraction later will reduce the refractive error by the degree represented in aphakia. Discission is to be followed by a later linear extraction	Oftentimes the operation of choice. A capsulotomy with forceps may be so satisfactory that complete absorption will occur of the lens fragments and subsequent discission be quite unnecessary	If linear extraction cannot be done a wide capsulotomy must be done with capsule forceps and the nucleus extracted. A complete iridectomy is to be performed if synechiae are present, or if a persistent prolapse of the iris cannot be replaced following peripheral iridectomy. The complication of vitreous prolapse during the operation may compel an iridectomy	See capsulotomy with iridectomy. An iridectomy is not to be done unless necessary. If persistent prolapse of the iris occurs a peripheral iridotomy may permit a satisfactory reposition of the sphincter. A large swollen lens often-times globular in shape may need an iridectomy for satisfactory extraction unless a wide dilation of the pupil is obtained	Parathyroid cataract after the age of forty (see below under complicata). This type of cataract before the age of forty has a friable capsule and this combined with the normally firm zonula makes an intra-capsular extraction quite improbable	Most unusual though in patients of later years the attempt may and perhaps should be made. Lens extraction with the erisophake is occasionally successful in these cases. The complicata in the later years of life should be extracted intra-capsularly if possible. The possibility of a weakened zonula as part of the complicata syndrome may be responsible for the high percentage of successes attained in these cases
Cataracta complicata All ages.	In the complicata of childhood and early adult life, a discission may be advisable. This is to be followed shortly thereafter by linear extraction. In high myopia if lens extraction is indicated this is the procedure to be carried out	If a complicata present in the early years of life has been preceded by a discission linear extraction is necessary. Some complicatas before the age of thirty years are sufficiently soft for such linear extraction.	Operation for this condition in the later pre-senile years of life with synechiae or when persistent prolapse cannot be corrected following a peripheral iridectomy.			
Pre-senile and senile cataract				See capsulotomy with iridectomy. Also preceding statement. In many of these cases a complicata in	A complicata at the age of forty and forty-five is occasionally extracted intra-capsularly...	

Cataracta complicata in early adult life as well as in the later years of life				ceps will be a necessary preliminary to the lens extraction. An intra-capsular extraction if attempted and unsuccessful, will result in a rupture of the capsule and demand a subsequent capsulotomy procedure. Iridectomy is to be planned as a subsequent step, however, and not as a preliminary maneuver unless the pupil cannot be dilated adequately. Post-extraction vitreous prolapse may make an iridectomy imperative	may be necessary because of some synechiæ though these can be broken down with a small spatula as a preliminary maneuver following a corneo-scleral incision The iridectomy is not necessarily a primary step though subsequent immediate complications may make it necessary. These same considerations apply to the cataract of parathyroid involvement also though not wholly similar.	(See immediately above)
Morgagnian cataract and cataracts which are hypermature.				See complicata. The ideal procedure if an intra-capsular is impossible or fails Iridectomy should be done, however even as a primary maneuver if post-operatively there is a possibility of iris prolapse Peripheral iridectomy may prevent this in some instances Satisfactory reposition of the sphincter of the iris when accompanied by a satisfactory peripheral iridotomy usually means an uneventful convalescence Post-extraction vitreous prolapse may make imperative a post-extraction complete iridectomy An iridectomy is generally indicated in the aged	See section on complicata. An iridectomy is indicated as a primary procedure when the iris will not remain replaced, if the pupil cannot be adequately dilated if synechiæ are present which cannot be broken down with a spatula or if the lens extraction is followed by vitreous prolapse The possibility of probable later postoperative iris prolapse is best combated by an immediate complete iridectomy An iridectomy is generally indicated in the aged	The ideal procedure in these instances An iridectomy should be done only if persistent iris prolapse occurs or when post-extraction vitreous presents, also if dilation of the pupil cannot be achieved for the lens extraction itself.
Grossly hypermature lenses		Morgagnian cataract with complete liquefaction of the cortex and with a precipitated shrunken nucleus is well operated by this procedure The capsulotomy should be done with capsule forceps	See linear extraction Though usually a keratome incision and the technique of a linear extraction is sufficient			If attempted will undoubtedly result in rupture of the capsule and compel a capsulotomy extraction.
Dislocated lens.	If congenital dislocation of the lens where surgery is deemed advisable, a preliminary discission will be necessary in some cases This must be followed by linear extraction	In congenitally dislocated lens following an earlier discission (See statement under congenital cataracts)	If posterior dislocation of the lens should occur during capsulotomy lens extraction an immediate loop extraction is indicated without regard to an iridectomy If iris prolapse does occur iridectomy should be done before the operation is completed	See capsulotomy extraction with iridectomy In congenital dislocation of lenses as in the arachnodactylia syndrome (Marfan's) optic iridectomies are to be done at times to permit aphakia vision, and not discissions. (See text)	Posterior dislocation of the lens may need an iridectomy due to the deep anterior chamber and a rigid iris before loop extraction can be carried out The condition of the iris the size of the pupil and the degree and time of vitreous prolapse controls the necessity for an iridectomy	An ideal procedure and a necessary procedure, especially in instances of recent dislocation, and with normal intra-ocular tension. Intercurrent dislocations while operating and vitreous presentation prior to the extraction should be completed with an intra-capsular loop extraction as expeditiously as possible

stances appear during the surgery, he must be able to change plans and procedures to meet the various conditions which develop.

Intra-capsular lens extraction is as yet not free from criticism. The discussion of its advisability is still in controversy by some operators. Many factors enter into this. The forcible rupture of the zonula in some patients may result in a low-grade iridocyclitis, for vitreous opacities have been described as developing in later years after an intra-capsular lens extraction; still this is no proof that the etiology of these opacities rests in the type of lens extraction which was carried out. Herniation of the vitreous should be no more common with this, than with any one type of extraction. Vitreous prolapse is probably a bit more common with the intra-capsular technique, but the loss of a bead of vitreous, while to be deplored, is not ordinarily fatal to an eye. There is no doubt that subchoroidal hæmorrhage is always a possibility in the presence of vascular disease, and it seems as if vitreous loss predisposes to the development of a subchoroidal hæmorrhage in such cases. This does not include all the cases of subchoroidal hæmorrhage, for many develop later, postoperatively, wherein the surgery has been apparently most uneventful. At the same time every patient would prefer, were he given the opportunity and the ability to decide, a satisfactory capsulotomy extraction without complications rather than an intra-capsular extraction with complications. The statement appears inane; it is applicable, however, in its relationship to the manual dexterity of the operator. The technique must be mastered though its perfection is achieved only after perfection has been developed in the capsulotomy extraction. The clear pupil, the absence of postoperative reaction, and the rapid convalescence are all characteristic of successful intra-capsular surgery. Capsulotomy surgery is more often complicated by a longer convalescence. Postoperative reaction is more common, and later discissions are necessary in as high as 30 to 40 per cent of cases. Several years after successful surgery, epithelial proliferation may appear and make necessary a discission at this late time.

A discussion of preliminary iridectomy is relevant here as well. The practice is fortunately becoming obsolete. A necessity for it may be present at times, but only when its function is not so much preliminary as in the nature of an optical iridectomy, hoping that the visual improvement obtained thereby (as in a nuclear cataract), will be satisfactory. Cases of nuclear cataracts in cripples, in arteriosclerotics, in cardio-vascular-renal cases, in asthmatics, and in those with secondary glaucoma, are not ideal cases for a lens extraction. In these a preliminary iridectomy functioning as an optical iridectomy may make the lens extraction unnecessary. This indication is second to that already discussed under secondary glaucoma wherein the progressive lens swelling was the probable cause of the glaucoma.

MORGAGNIAN CATARACT

By this is meant a hypermature lens, one in which there has been such extensive liquefaction of the cortex that the condition present is a capsule sac of fluid, usually milky white in appearance, with a brown crenated nucleus lying at the bottom of the sac. This is the highest degree of hypermaturity. Intra-capsular lens extraction with forceps is practically impossible in these cases because the capsule will rupture and thereby

compel a capsulotomy technique. The nucleus is the one solid part needing extraction, so that the greatest majority of these cases are best operated by a linear extraction and through a keratome incision.

DISLOCATED LENSES

In discussing the surgery of dislocated lenses, there are four general conditions which need consideration. (1) Congenitally dislocated lens, often bilateral and incomplete, (ectopia lentis); (2) traumatic dislocations into the vitreous; (3) traumatic dislocation into the anterior chamber, or through a ruptured sclera into the subconjunctival space; and (4) dislocation of the lens while in process of cataract extractions.

The first, that of congenitally dislocated lenses, is often bilateral and usually incomplete. The lenses are ordinarily without opacities of any clinical significance. In some cases the dislocation (ectopia) is so pronounced that the patient can wear aphakia glasses with good vision. In many instances a small optical iridectomy, of the sphincter only, will give a clear and satisfactory pupil for an aphakia correction. If the lens is displaced down and inward, an optical iridectomy at the inferior nasal part of the pupil will enable the patient to utilize the dislocated lens. The size of the pupil, however, and the position of the dislocation controls this wholly. Ectopia lentis is usually bilateral. Apparently the dislocation is most common up and in, but the lens may be displaced in any direction. Ectopia lentis may be a part of the Marfan syndrome of arachno-dactylism In these, aphakia vision from an iridectomy is certain; an iridectomy is a less serious operation. Discission in these cases has a rather high percentage of complications; attempted intra-capsular extraction is always accompanied by complications, and the lenses, if not operated, usually remain clear for life. Cases will appear with an incomplete dislocation, and in these the advisability of surgery must be seriously considered.

Surgery means an initial discission, which may need repeating, the possibility of irrigating lens fragments from the anterior chamber, and the bare possibility of a later keratome incision for capsulotomy. Intracapsular loop lens extraction may be attempted in those with a floating type of dislocation, the lens being adherent to the ciliary body only by a few remaining filaments of the suspensory ligament. When discission is to be carried out, the operator must be careful not to complete a posterior displacement of the lens backward into the vitreous as the result of his manipulations with the knife needle. These lenses are insecurely attached and may be further dislocated during a discission.

Traumatic dislocation of the lens, into the vitreous, is usually an emergency operation. There is one qualifying point, however. An acute secondary glaucoma may develop immediately after the trauma, and if not then, will most certainly develop later. The time, therefore, for the surgical extraction of the lens, if it is to be done, is after one has succeeded in lowering the tension of the initial attack of secondary glaucoma, while the eye is quiet and before the chronic form has intervened. In some instances this can be achieved within two or three days, in others it may take somewhat longer. Even under the best of conditions, it is not uncommon to have phthisis bulbi develop rather early after the lens extraction, even without dangerous vitreous loss or with any other complication. Also in spite of

the fact that even though the surgery may be immediately successful a secondary glaucoma may still develop demanding, later, a trephining for its correction. Immediate hospitalization is indicated, sedatives to stop the pain and quiet the shock of the patient, hot compresses, dehydration and sufficient miotics to bring the pupil to a pin-point and to hold it there. In many of these cases when the patient is admitted to the hospital, the cornea is so clouded from the hypertension that one cannot determine the position of the dislocated lens in the vitreous. In others, it will be possible to make an exact localization. As the tension recedes the pupil may be opened sufficiently wide so that satisfactory fundus studies can be made. Adrenalin and glaucosan are of no value in this form of secondary glaucoma. The anterior chamber is deep, and vitreous is often in the anterior chamber. Corneal paracentesis is also usually valueless.

A conjunctival flap of the van Lint type should be prepared before the corneo-scleral incision is made, so that as soon as the lens extraction is done, this can be pulled down and sutured to coapt the lips of the section firmly and closely. A superior iridectomy is necessary, granted that the position of the dislocated lens is known accurately. A large lens loop is to be passed directly into the vitreous, through as wide a corneal section as is possible, hoping to engage the lens, and with the section as a support, to bring the lens up and out by means of the loop. The operator must work quickly but gently, and the surgery should be done under general anesthesia, so that the eye can be held firmly by the assistant with forceps or by means of a bridle suture. It is almost inevitable that some vitreous will be lost, but the amount lost can be reduced to a negligible and not dangerous minimum by careful localization of the dislocated lens, and by gentle manipulations Old and long-standing dislocations with the lens firmly attached in its dislocated position and in secondary glaucoma are best treated by enucleation if the patient has one good eye remaining. In certain cases, failing this, corneo-scleral trephinings were attempted to hold the vision remaining, but in each instance the outcome was failure. A less completely dislocated lens when still adherent to the ciliary body by a portion of its suspensory ligament offers a much better prognosis. Accurate localization of the lens at the time of the surgery, preparation of the conjunctival flap, the adequate corneo-scleral section, the complete iridectomy, and the extraction with the loop are all similar. Many of these cases are complicated by iridodialysis. The position of the lens controls the position of the corneal section in that the incision must be made at a point opposite to where the lens still remains attached with its suspensory ligament. This means if the dislocation is downward, the incision must be upward, or if the dislocation is upward and the lens still remains hinged above, then the corneal section should be at the limbus below. Those cases with lateral residual attachments can usually be handled by a superior section though it may be necessary to swing this to one or the other side, *i. e.*, toward 3 or 9 o'clock.

The extraction of a lens dislocated into the anterior chamber is even more of an emergency procedure than are those cases with a dislocation of the lens into the vitreous. Even if secondary glaucoma is present in these cases, the surgery should not be postponed, for the hypertension will continue until the lens has been removed. These cases are due to a compression of the eyeball against the walls of the orbit so that the sudden force exerted

is almost wholly behind the suspensory ligament, driving the lens through the pupil as the zonula ruptures; also, it is rather likely that impact to the sclera should occur from a blunt object small in circumference though with considerable force. There is one important condition, however, which must be correctly differentiated; that is blood staining of the cornea. Cases have been admitted to the hospital for surgery with a diagnosis of anterior dislocation of the lens which proved to be simply blood staining of the cornea when examined with the slit-lamp.

The surgery indicated (see Anterior Dislocation of the Lens) is an immediate loop extraction through a large corneo-scleral incision without iridectomy. Miotics should be used before the surgery (as well as after) preventing the lens from falling through the pupil into the vitreous as soon as the anterior chamber is opened by the corneo-scleral incision. The first stage of the operation is to close the pupil, the second to prepare a conjunctival flap, and the third a keratome incision made with a broad keratome without damaging the lens. The section is then completed with a pair of sharp scissors so that the section is sufficiently large to permit a loop extraction without difficulty. It may need to include the entire upper half of the limbus. As soon as the section is completed, gentle pressure should be applied to the limbus below so that the lens can be moved toward the corneo-scleral incision. A broad spatula or a lens loop can be placed behind the lens depressing the posterior lip of the wound and acting as an inclined plane so that the equator of the lens above can slip out of the anterior chamber rather readily. The moment the lens is engaged in the section, there is no further danger of iris prolapse, and pressure below the center of the cornea with the blunt end of a lens hook will permit continued extraction of the lens. As soon as it has been expressed, the operator should see that the iris lies free, instil eserin, and close the corneo-scleral incision with the conjunctival flap formed.

The extraction of a lens which has been dislocated extra-ocularly through a rent in the sclera, usually lying subconjunctivally, is more of a problem. Most of these eyes should be enucleated immediately. The rent has occurred through the area of the ciliary body and may pass into the cornea. Iris or ciliary body prolapse is usually present at the same time. Intraocular hæmorrhage may be severe. Some cases when first seen are wholly sightless, and in such instances an enucleation is the only operation indicated. If light perception is present, one may consider the advisability of repair surgery, but this is dangerous and may be regretted later because of sympathetic ophthalmia. A low grade iridocyclitis may develop with secondary glaucoma, and the eye lost through this. The conjunctiva is to be incised, the lens removed, the iris and ciliary body presenting resected, the sclera sutured with No. 6-0 catgut, and lacerations which have continued into the cornea covered with conjunctival flap. Because of the tremendous trauma, these cases are usually hopeless, and an enucleation is probably indicated in all except those under most extraordinary circumstances.

A dislocation of the lens which occurs during a cataract extraction is, in the final analysis, one of the complications to be considered under that heading. Its mention is made here only because it is relevant.

CHAPTER XIX

THE TECHNIQUE OF THE CATARACT OPERATIONS. INDICATIONS AND CONTRAINDICATIONS FOR VARIED PROCEDURES.

DISCISSION

The indications for the operation rest upon the absorption of the lens after its fragmentation and liquefaction through contact with the aqueous. The cortex of the lens is seldom a problem. The nucleus, however, may be firm at times and fail of complete absorption. Under such conditions it will have to be removed after absorption has ceased. This needs a secondary operation with a keratome, and a removal of the mass with capsule forceps. During these manipulations, this mass may fall behind the iris, producing irritation subsequently, and even secondary glaucoma. It is far better to remove it in its entirety, if possible, than to attempt further discissions even with de Wecker scissors.

This matter of cortex absorption is hardly one of phagocytosis. In 1911, Clapp[1] called attention to the probability of an autolytic ferment[2] "being present in the lens and the aqueous, acting upon the insoluble proteids, changing them over to a soluble compound, after which reaction they could be carried off by the circulation of the blood and the lymph. Goldschmidt[3] confirmed Clapp's opinion by a slightly different technique and also called attention to the fact that frequent needling caused an increase in the amount of proteid splitting ferment. There is undoubtedly a fair percentage of insoluble albuminoids present in the lens which must be changed over to a soluble condition before they can be carried off. It seems that both experimentally and clinically, evidences are present of some protein-splitting action of the aqueous when the lens capsule is opened and the lens fibers traumatized.

The anesthesia necessary depends upon the age of the patient and the condition being operated. General anesthesia is necessary in all infants and in children, usually up to the age of ten or twelve years. Patients over twelve years of age can be operated, ordinarily, under local anesthesia. Several instillations of 4 per cent cocain or of a 1 per cent pontocain solution, at five-minute intervals, are sufficient.

Various knife needles have been recommended for the operation. The Bowman knife needle and the sickle-shaped Ziegler modification of the original Hays knife are the most common in use. Regardless of the instrument used, the purpose of the surgery is to pass the knife into the lens, obtaining a deep penetration, but without entering the vitreous; that is, there should be no through-and-through perforation of the lens. Ziegler recommended the through-and-through perforation, hoping to prevent secondary glaucoma, but deep penetration of the lens without entering the vitreous is preferable. Wilder[4] also condemned the Ziegler discission, pre-

[1] Jour. Am. Med. Assn., 56, 807, 1911.
[2] Clapp, Cataract, Etiology and Treatment, Philadelphia, Lea & Febiger, p. 164, 1934.
[3] Arch. f. Ophth., 88, 405, 1914.
[4] Trans. Am. Acad. Ophth. and Otolaryng., 1925.

ferring discission and such subsequent linear extraction as is necessary. He called attention to the occasional case wherein the posterior capsule must also be incised, and also mentioned the necessity for removing the nodule of an anterior polar cataract from the anterior chamber while operating these conditions, in that this nodule will fail of absorption and will cause irritation if it is not removed. The lens incision is either to be cross-shaped or V-shaped. The eyeball is fixed at a point on the limbus opposite to the site selected for the insertion of the knife needle, and the needle passed into the anterior chamber at the limbus with its flat surface parallel to the plane of the iris. If it is thought advisable, the needle may even be introduced subconjunctivally. Occasionally it is passed directly through the cornea, and while this is perhaps an easier procedure, it is not recommended, in that anterior synechiæ may develop at this place from the resulting trauma and in the course of the postoperative healing. The pupil must be widely dilated with atropine. The operator can see the greater surface of the lens,

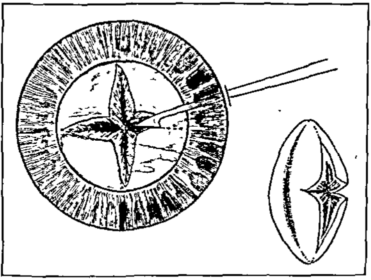


Fig. 429 —Discission of the lens.

the iris is not as readily injured, and the danger of postoperative iritis will be minimized. As the blade of the knife is carried through the limbus, it is moved across the face of the lens to the opposite angle of the anterior chamber for a crucial incision, the blade still being held on the flat (Fig. 429). The tip is brought as close to the edge of the pupil as possible without touching the iris. The cutting edge of the blade is then turned backward, facing the lens, and the tip and cutting edge thrust into the lens with a quick movement. The handle of the knife is then elevated so that the edge is carried through the capsule, the cortex, and well into the nucleus with as long an incision as it is possible to obtain. It should extend from one edge of the pupil to the opposite edge. The vertical incision is now made following this horizontal one. The edge and the point of the knife are lifted free from the lens substance and carried to the lower part of the pupil, and the same maneuver repeated, this time with the cutting edge passing upwards across the anterior surface of the lens. After the second incision has been

made, the knife is turned again on its flat and removed without the loss of aqueous. If a V-shaped incision is to be made, the first arm of the incision should start below at the lower part of the pupil and the first cut made upward and toward 10 o'clock. The second cut starting at the point of the first should be made upward, and diverging toward 2 o'clock. Lens masses which can be moved well into the anterior chamber become absorbed most rapidly.

Further atropine is instilled and the eye dressed for twenty-four hours. Under ordinary circumstances the dressing may then be removed and atropine instilled sufficiently often to keep the pupil dilated and hot compresses used to reduce the postoperative irritation. It may be that 3 to 5 per cent solutions of dionin (ethyl morphine hydrochloride) assists in hastening absorption. The tension of the eyeball must be carefully observed. A tendency to a rise in tension is neither uncommon nor dangerous. If it continues, however, or increases, then it will be necessary to evacuate the contents of the anterior chamber through a linear extraction.

A repetition of a discission may be done if it is necessary. Further repetitions, however, must be seriously considered. If the vitreous has not been damaged at any time, and if the postoperative recovery has been uneventful, the possibility of complications is much less. These cases, however, with postoperative irritation should be completed with a linear extraction if it is possible. The author would much prefer a linear extraction following a discission rather than the repetition of a discission, especially in cases of older patients wherein absorption is proceeding slowly.

An initial discission followed by linear extraction of the opaque lens masses two to four days thereafter has been recommended by several ophthalmologists. The combination of the two operations has many definite advantages and can be utilizes with satisfaction when necessary.

Complications of and from a discission are fortunately not common. A necessity for repeated discissions is perhaps to be considered as a complication, though there are many other factors which modify this. These factors are connected with inadequate opening of the capsule and the lens at the initial operation.

The complications most commonly seen are: (1) Cessation of the absorption as the result of postoperative irritation; (2) low grade postoperative iridocyclitis; (3) slow absorption because of the age of the patient, and of the preëxisting density of the lens itself, or of plaque-like formations in or on the lens: and (4) remains of capsule tags and remnants and organized exudate as a permanent complication. Secondary glaucoma is probably the next most common complication. A through-and-through incision of the lens into the vitreous is not a guarantee against the development of secondary glaucoma; instead, damage may occur to the vitreous with later an iridocyclitis and chronic in type, and even a retinal separation. If a secondary glaucoma does occur which cannot be controlled by dehydration, by hot compresses, and with atropine, an immediate linear extraction must be done. Corneal paracentesis will give a transient lowering of the tension, but it may force lens fragments even more firmly into the angle of the anterior chamber. Miotics may be tried, but it is doubtful if they will be of any value. Clapp calls attention to a chronic form of glaucoma which may result from needling. He states that this usually occurs several years later and apparently results from capsular bands contracting and narrowing

the filtration angle. Postoperative irritation, iritis and iridocyclitis as stated, while not common, do occur, and these cases do not seem to be connected with any infection. They are more likely the result of an irritation, allergic in nature, from the changed lens proteid. Atropine and hot compresses are to be used, lens proteid desensitization to be carried out and sodium salicylate given in 40 grain doses, daily, by rectum. The distressing point of this type of iridocyclitis is that it is not infrequently followed by phthisis bulbi, especially in the young and when repeated discissions have been done.

The discission of retained lens cortex and of capsule remnants, following capsulotomy operations, will be discussed under the complications of that procedure.

LINEAR EXTRACTION

There has been some confusion in the literature in regard to this term. By linear extraction is meant the extraction of a soft cataract regardless of the age of the patient. The types of cataract to which it applies are the congenital cataracts after discission; traumatic cataracts early in their course; the cataracts of dinitrophenol, and many of the similar types of cataract in individuals below the age of thirty-five years; the extraction of Morgagnian cataracts and the extraction of lens fragments following a discission for any condition where secondary glaucoma is present from a rapid swelling of the lens or from the presence of lens cortex in the anterior chamber angle. Complicated cataracts in young adults can frequently be operated by linear extraction. Many of these cases have fluid vitreous, and it would be unwise to attempt other types of extraction. The wide capsulotomy will permit the aqueous to affect the retained cortex remnants, and if one is successful in removing the nucleus, the operation is more or less a combination of wide discission and linear extraction simultaneously. A subsequent discission may be necessary, but the necessity for this is at least minimized if the pupil can be kept well dilated during convalescence and is not to be done until the eye is quite white.

The rules for the anesthesia for linear extraction are the same as those which apply to a discission. With this exception, however, for if there is any doubt as to the probable behavior of the patient on the operating table, a general anesthetic, preferably avertin, should be used. If under general anesthesia, a blepharostat may be utilized. If the case is being done under local anesthesia, however, it is better that the lids be held by a capable assistant, the lower lid depressed by the assistant with the thumb, and the upper lid raised up and lifted away from the orbit by a lid elevator of some acceptable type. The pupil must be well dilated *ad maximum*, in that the sphincter of the iris is to be conserved if possible.

The position which the operator should assume for passing the keratome has been already discussed under iridectomy. That position wherein the operator stands at the patient's right side, invariably facing him, passing the keratome from above, seems most logical, and is recommended. A conjunctival flap may be formed first, as is classical for a corneo-scleral trephining or for an iridencleisis operation. If not, the tip of the keratome should go directly through the conjunctiva at the limbus because a subconjunctival (flap formation) introduction of the keratome will make the removal of the lens substance more difficult. Some authors recommend the

introduction of the keratome through the corneal tissue itself, as close to the limbus, however, as it is possible to be, in that the ledge of anterior chamber immediately behind the entrance of the keratome and above the iris may prevent an iris prolapse. While this may be true, the author prefers introducing the point of the keratome slightly more posterior to this, so that it is passed actually through the most anterior insertion of the conjunctiva. The eyeball is fixed below, opposite to the position of the incision, and the point of the keratome carried through the limbus perpendicularly, as is customary. As soon as the tip appears in the anterior chamber, the handle is carried posteriorly and the blade passed into the eye, parallel to the plane of the iris, with a continuous motion until the maximum incision desirable has been obtained, that is, one from 6 to 8 mm. in width. The keratome is then slowly withdrawn, permitting the aqueous to escape, but slowly, so the iris will not be floated out by the aqueous.

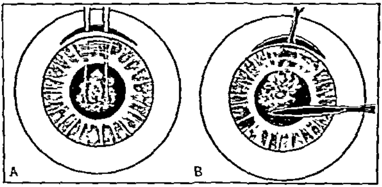


FIG 430 —*A* capsulotomy for linear extraction; *B*, removal of cortex.

In some very soft lenses it is permissible to open the anterior capsule with the tip of the keratome before withdrawing the keratome. Then, as the keratome is withdrawn, much lens substance will follow with the aqueous. In general, however, the capsulotomy should be done with the capsule forceps. With the eyeball again fixed and moved downward, the toothed Kerrison or Fuchs type of forceps is passed into the wound with its blades closed. This is to be carried to the center of the pupil; there the blades are permitted to open and the portion of the anterior capsule between the blades of the forceps torn out and removed as in Figure 430, *A*. The capsulotomy should not be done so vigorously that a dislocation of the lens occurs.

In very soft lenses following the capsulotomy, an anterior chamber irrigator will remove all of the lens substance, giving a clear, round, black pupil. The tip of the irrigator is introduced into the wound at one of its extremities, the wound made to gape by a slight posterior pressure, and the fluid allowed to run with medium force. A pump-like action will be achieved by this irrigation if the operator will alternately increase and decrease the pressure which he exerts against the posterior lip of the wound. If simple irrigation is proving unsuccessful, then a loop or spoon should be placed in the wound, causing it to gape slightly, and the lens masses remaining removed by pressure against the cornea below with a hook or with a smooth broad spatula as in *B*. The hook or the spatula is stroked upward toward the incision, milking the lens masses out through the incision up

the inclined plane of the spoon or loop. Vitreous prolapse should be avoided if it is at all possible. It is better to chance a later discission than to permit the prolapse of vitreous through continued attempts to remove retained lens masses. In some of the older patients and in the cataracts of longer standing, after the major portion of lens fragments have been removed, it is sometimes possible to grasp the edge or fringe of the capsule remaining with a smooth non-toothed capsule forceps. This may make possible the removal of the entire capsule, certainly a major portion of it.

Barkan's[1] procedure for linear extraction emphasizes maximum dilation of the pupil by the subconjunctival injection of adrenalin, an oblique incision 1 or 2 mm. from the limbus, and the oblique introduction of the keratome to produce a valve-like opening. As Green and Beisbarth[2] say: as soon as the aqueous has reformed and some degree of intra-ocular pressure has been reëstablished, no amount of manipulation possible, or instrumentation, will result in a prolapse of the well retracted iris; also owing to the associated hypotony there is very little if any loss of vitreous.

The toilet of the wound completes the operation. The iris is to be smoothed into place, a limbal incision freed of any tags of capsule, atropine instilled, and a Barraquer dressing applied. A peripheral iridotomy may be necessary if the iris tends to prolapse. If a conjunctival flap had been prepared prior to the incision, two sutures are used to close this. The postoperative treatment consists in the continuation of the atropine, the use of dionin, and the application of hot compresses as soon as possible to assist in the absorption of that cortex remaining and to cut down the operative reaction.

Complications of Linear Extraction.—Iris prolapse and prolapse of the vitreous are the most common complications which occur. If the iris cannot be replaced satisfactorily at the end of the operation, that portion which prolapses will have to be resected with a clean coloboma. In replacing the iris it is necessary that one be gentle to prevent postoperative iritis. A necessary coloboma above, because of the iridectomy, is not a distressing complication; it is covered by the upper lid, but if possible it should be prevented. A coloboma, however, which would be in the line of the palpebral fissure, will cause considerably more distress; therefore, if the linear extraction must be done at any other place than that on the limbus above, the operator should be particularly careful to prevent iris prolapse. Meller and some of the other operators routinely do their linear extraction through an incision in the lower limbus. The reasons for this are that it seems to minimize iris prolapse, and the field of operation is better exposed If it should seem advisable to operate through the lower limbus, then the surgeon should stand at the head of the patient, changing his position relative to the eye to maintain the same relationships as before mentioned.

Vitreous prolapse is not rare, especially when it is fluid. Ordinarily it can be prevented by operating as gently as is possible. Older lenses, those with a tough capsule, and when complicated by synechiæ and with calcified plaques, are more difficult to remove, and in these cases there may be a prolapse of some vitreous. Excluding these cases, the prolapse of normal vitreous with its semi-solid consistency is a rather serious complication, in that one must cease the further attempt at removing lens fragments; also

[1] Am Jour Ophth, Ser. 2, vol. 15, February, 1932.
[2] Am. Jour. Ophth., Ser. 3, vol 16, July, 1933.

the reposition of the iris is difficult in such instances. Healing is occasionally delayed because of gaping of the wound. If this does occur, a suture should be placed, the vitreous cut off cleanly, and the suture tied down immediately thereafter.

At times the total lens is more sclerosed than anticipated, or the nucleus is large and hard and difficult to extract. If this appears, the incision should be lengthened with scissors immediately, at one or both of its extremities, to permit satisfactory expression of this, thereby minimizing the possibility of vitreous prolapse by the pressure which would be necessary to deliver this nucleus through a smaller incision. If a loop extraction is probable, the operator should prepare a conjunctival flap, immediately introducing his sutures for instant tying after the extraction of the lens. Naturally, this complication applies only in those instances wherein the lens is fairly firm in its consistency; therefore it is applicable to the early total cataract of young adults (Meller).

MAJOR CATARACT PROCEDURES

The capsulotomy extraction and the intra-capsular lens extraction are to be considered as the major surgical cataract procedures. Both of them have many points in common, and to conserve time and space, those which are common to all procedures need be mentioned only once, although reference will be made to those portions of a technique under consideration which has been previously outlined. This is especially true in regard to the discussion of an iridectomy, and as this has been well covered before (Chapter XVII) it needs no repetition.

(1) The anesthesia; (2) the positions of the operator and assistant; (3) the fixation of the eyeball for the corneo-scleral incision; (4) a discussion of the bridle and lid sutures; (5) the incision itself; (6) and the conjunctival sutures are so definitely common to all procedures that it seems wise to discuss these immediately.

Anesthesia. (See pages 15–19).—The anesthesia is either local or general. The use of avertin depends upon the physical condition of the patient, his disposition and temperament, and upon certain other less common contigencies which may appear, as the unfortunate individual who has had one unsuccessful cataract extraction already done, with perhaps the loss of that eye. *Difficulties and complications are minimized when a possible* lack of coöperation (on the part of the patient) is made impossible through the use of general anesthesia. The stormy post-anesthetic period of ether anesthesia with its agitation, nausea and vomiting, contraindicates ether for cataract surgery. The postoperative course of avertin, however, is quite different. The patient is quiet, nausea and vomiting are most uncommon, and even if it has been necessary to augment the anesthesia with venethen, this does not cause, of itself, nausea or vomiting, and the recovery periods are so brief that agitation and unruliness are practically absent. If avertin alone is being used, a retrobulbar injection may be added, but an injection of novocain into the orbicularis, of the lids, and of the conjunctiva is always necessary. At the same time, because of the general anesthesia, a bridle suture must be used so that the assistant can hold the eye down and control it otherwise as is necessary. This demands novocain injection into the superior rectus muscle.

If there is any limitation in satisfactorily separating the lids, due to a narrow palpebral fissure, the surgeon should not hesitate in performing a canthotomy at the external canthus. Traquair[1] emphasized this some time ago. At the same time he also spoke of the lid sutures in the center of the lids, a few millimeters above the ciliary margin, as well as the advisability of a bridle suture in the superior rectus muscle.

Control of Lids.—For all major cataract procedures it is best to dispense with a blepharostat and to have an assistant depress the lower lid with his thumb and elevate the upper lid with a lid elevator.

Rules for anesthesia in major cataract procedures in general are set forth in the following table.

	Preoperative	Operative
Local anesthesia	Allanol, nembutal, and phenol barbiturates, the night before and the day of the operation Bromides and codein also may be necessary. The former for some time pre-operatively, the latter immediately pre-operatively.	Cocain instillations, retrobulbar injections of novocain and adrenalin Akinesia by van Lint-Rochat injection of the orbicularis or the O Brien block of the facial nerve Novocain injection of the lids if necessary, novocain injection of the superior rectus for bridle suture Ballooning of the conjunctiva with novocain assists in cutting a conjunctival flap and probably makes an iridectomy painless, or less painful
Avertin anesthesia without adjuncts.	For general surgery morphine before avertin is ideal, in fact almost necessary. For cataract surgery, however, it is definitely contraindicated The barbiturates to tolerance seems to give best results.	Cocain instillations injection of the lid margins, superior rectus injection for the bridle suture, akinesia and retrobulbar injections if necessary. Ballooning of the conjunctiva with novocain assists in cutting a conjunctival flap and will anesthetize the iris for the iridectomy
Avertin anesthesia with adjuncts as venethen or chloroform.		Superior rectus injection for the bridle suture Ballooning of the conjunctiva with novocain assists in cutting a conjunctival flap, and anesthetizes the iris.

Recently Percy Fridenberg[2] read a paper on traumatisms to the eye which occurred while operating, calling attention to certain relevant factors. These which are anatomically connected with the safety of the eye normally and in health, Fridenberg stated, become hazards during ophthalmological operations. For example, the reflex contraction of the orbicularis which normally protects, now endangers the eye; and the position of the eye within the orbit with its limited exposure renders surgery difficult by reason of inaccessibility and a narrowing of the field of surgery. Fridenberg spoke of three factors: (1) the patient, (2) the operator, and (3) the instruments. Formerly, before the days of a less satisfactory anesthesia, the patient involuntarily and unconsciously assumed the rôle of an assistant to the operator. The safeguards which we have are aimed toward making this not only unnecessary but also impossible. In so far as the operator is concerned, there are three factors here of importance, again quoting Fridenberg, fatigue, eyesight or visual acuity of the operator, and satisfactory illumination. It was with "3" however, that Fridenberg was most concerned: that

[1] Trans Ophth Soc. United Kingdom, 50, 565, 1930
[2] Sect. Ophth, New York Acad. Med, May 17, 1935.

is, the dangers and the damages from faulty instrumentation. In regard to this, the speculum is no doubt a serious matter. Arlt spoke of it as a dangerous instrument and felt that control of the lids is far more satisfactory when achieved through the fingers and the lid elevator of an assistant. If the O'Brien block of the facial nerve is done and when the patient is under general anesthesia, the use of the blepharostat is much less dangerous; it is unwise to use it with local anesthesia. Many of the complications which occur, however, are not due to a pinching of the orbicularis fibers, but because of a spasmodic combined pull of all the recti backwards, and an orbicularis block does not control this.

The Position of the Operator and His Assistants.—The position of the operator depends upon two or three various factors. One of these is ambidexterity. The second is variable, in that some ophthalmologists operate upon the left eye of the patient from the left side of the bed or the table. The third is more universal, in that, in the absence of ambidexterity, all operators must operate upon the right eye standing above and toward the right side of the patient's head. Ambidexterity is a most desirable faculty if present to a full degree. Ophthalmological surgeons develop a certain degree of this, but the importance of the cataract incision is so basic that it should not be made with the left hand in a right-handed individual, unless the operator is equally facile with that hand. A statement made before, and one which appears so commonly in the literature. "The incision is the secret of cataract surgery," is absolutely true. In general, therefore, the operator will universally stand close to the shoulder of the patient on the right side of the bed or table for left eye operations, with his cataract knife in the right hand and his fixation forceps in the left one. When operating upon the right eye, he will move his position to the head of the patient immediately behind the right eye, that is slightly toward the right side of the body. The left-handed individual, of course, would exactly reverse this. Surgery must occasionally be done through an inferior limbal incision. In such an instance, the position of the operator remains the same except the fixation of the eyeball is obtained, now, slightly above the horizontal meridian of the cornea at the limbus. As soon as the incision has been made in a left eye, the surgeon should move his position toward the head of the table so that the capsule forceps or the lens loop can be best used with his best hand, that is, with his right hand and from above. When operating upon the right eye, it will not be necessary to alter his position to any degree.

The assistant should always stand at the left of the table or the bed, holding the upper lid with a lid elevator together with the bridle suture and controlling the eyebrow with his right hand and retracting the lower lid with the thumb of his left hand. In this way he can always release the lower lid, thus freeing his left hand for assisting the operator with sponging, the holding of the eyeball, for taking an instrument from the operator's hand, for controlling sutures, and many other similar probabilities. The assistant's left arm is to be held close against the body of the patient so that the operator's right hand and arm can move over it without any limitations. The direction of the assistant's gaze is always up and into the superior cul-de-sac so that he is the first to see vitreous presenting, to note the dislocation of the lens, and to appreciate voluntary movements of the eyeball by the patient. If vitreous presents or vitreous loss is impending,

it is the assistant's duty to lift the lid out (not up) and away from the eyeball, both the upper and the lower, as a matter of fact, and to release the bridle suture so that the eyeball will rotate upward spontaneously. In most instances, this is sufficient to allow the vitreous to again settle back into the vitreous chamber and prevent any catastrophe. Subsequent depressions of the eyeball then, depend upon the operator's judgment, and the bridle suture should be turned over to him for the manipulations which are still necessary in the case. The assistant should keep his vision glued upon the eyeball from the start to the close of the surgery and is only valuable to his chief when he can carry out his part of the task in this way. Drying of the cornea is not at all uncommon, and the assistant should watch this and prevent it by an occasional drop of normal saline with a medicine dropper, not using a cotton wound wet applicator. The cornea can be denuded very readily when under the effects of cocain. A statement here is also relevant as to sponging for hæmorrhage. Too often the assistant wipes instead of tamponing. The pressure of a pointed moistened cotton sponge, spindle-shaped, is effective, and a wiping motion does not increase the absorption of blood; instead it traumatizes tissues and further increases the hæmorrhage. The illumination from some type of a focused hand light should come from the right side of the table or the bed and be so directed that the reflected rays glance off and away from the direction of the gaze of the operator.

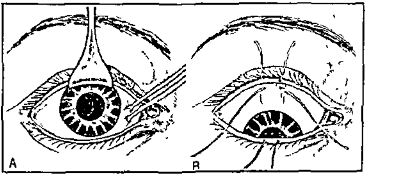


FIG. 431.—Fixation, lid and bridle sutures.

Fixation.—The eyeball should be grasped near the limbus at the point just below the position of the counterpuncture, that is, just below or at the horizontal meridian. See Figure *A*. 431 A broad fixation forceps which grasps the conjunctiva alone is superior in some instances. In many cases, however, because of the delicate conjunctiva, which comes on with senility, it is necessary to use toothed scleral grasping forceps as presented by Elschnig and Gifford. Even with these the conjunctiva frequently tears before one has a satisfactory grasp. It is foolish to proceed with the cataract section unless the eyeball is well controlled by the fixation. Fixation below permits a disconcerting dipping of the eyeball, and the wheel-like rotation which also results will make the section much more difficult. The operator will know that he has a satisfactory fixation if he can elevate the eyeball from the orbit by means of the fixation forceps, that it is firmly grasped and can be well controlled. It is not uncommon to have fixation so roughly applied and so continued during the corneal section that this is

responsible for a premature dislocation of the lens. Firm control of the eyeball is necessary, but the eyeball should not be compressed with the fixation forceps, nor should it be injured by repeated jabs in an attempt to obtain adequate fixation.

Occasionally a hematoma will develop in the conjunctiva as the result of fixation or edema of the conjunctiva from the injection or the instillation of drops, making fixation difficult. A clean incision through the conjunctiva and satisfactory fixation to the episcleral tissue is much better than to attempt a cataract section without firm fixation. Two-bladed fixation forceps are needed at times, and even broad-based toothed fixation forceps. Angelucci recommended fixation of the eyeball under difficult circumstances by grasping either the internal or the external rectus through the conjunctiva. This may be necessary in old patients with easily torn conjunctiva, but it permits nevertheless considerable distressing motility to the eyeball. When the patient is being operated upon under local anesthesia, he or she can assist by keeping the eye down, but even this is difficult. Making the section tends to pull the eyeball up and the patient must make a conscious effort to hold it down. When the operation is being done under general anesthesia, the entire fixation problem is decidedly simplified.

The Bridle and Lid Suture.—A bridle suture through the superior rectus muscle is absolutely essential in surgery under general anesthesia. Silk sutures as bridle sutures through the inferior rectus as well, and occasionally through the internal and external recti are necessary at times to obtain satisfactory fixation. A section cannot be made properly until fixation is adequate; this is so basic, that the success of the surgery may depend upon it. When operating under local anesthesia, it is almost as valuable; in fact some operators not only introduce it but also tie it lightly to the lid elevator. The injection for this is made by the introducing of 6 to 8 minims of novocain and adrenalin solution well back into the tendon of the superior rectus. This tendon is grasped through the conjunctiva with forceps as far posterior as is possible, and the needle point carried for at least 2 to 2.5 cm. posteriorly before injecting the solution to prevent a gross ballooning of the conjunctiva. Without releasing the hold which one has had during the injection, the syringe is laid aside, and a No. 1 braided silk suture in a rather large needle is passed through the conjunctiva and the tendon of the superior rectus. The needle then should be removed, both ends of the suture grasped, and the eye rotated downward with the suture to be certain that it is through the muscle and not through the conjunctiva alone. The assistant can hold this suture, with the lid elevator, between his thumb and index finger very easily controlling at all times the position of the eyeball as is desired by the operator. It is, in general, rather dangerous to compel the patient to look down constantly, that is, if he or she cannot or will not look down in a natural and unstrained position. It is better in such instances to extract with the patient looking straight to the front. When the operation is completed, one end of this suture is cut close to the muscle and withdrawn. This can be done even with the eyelids closed.

Lid sutures through the mid-point of the lid margins, immediately posterior to the line of the cilia are valuable adjuncts in cataract surgery. They play no great rôle at the time of the operation itself, but they permit a satisfactory postoperative closure of the lids, preventing them from opening beneath the dressing. This is important in all instances wherein orbicularis

paralysis of any type has been done. The possibility of the lids separating beneath the dressing must be prevented because most serious consequences will develop if this should occur. Figure 431, *B* shows the three sutures to which reference was made, the bridle suture through the conjunctiva and *the superior rectus, the upper lid white silk suture, and the lower lid black* silk suture. The bridle suture is to be of braided black silk, the other two, however, may be of a twisted silk. These lid sutures are to be placed immediately after the bridle suture has been introduced. Peter suggested that the upper lid suture be of white silk to prevent confusion and to permit rapid identification.

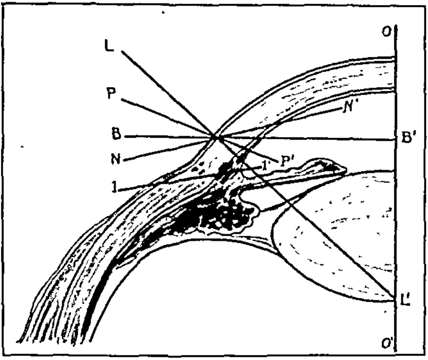


FIG. 432 —Direction of a cataract section (After Beard, courtesy of P Blakiston's Son & Co)

The Cataract Incisions.—The incision of a cataract section has gone through many interesting phases. Beard[1] has discussed it historically in great detail. It is remarkable and interesting to see the variability of the sections which have been considered from time to time. The modern ideal incision is not far removed from some of these. A statement was recently made to the effect that failing an ideal section the operator has some faint consolation in knowing that that section he obtained in the case, regardless of his dissatisfaction with it, was at one time undoubtedly recommended as the section of choice.

Figure 432 modified after Beard, is a diagrammatic sketch of the possibilities present. *I*, I^1 is the site of the sclerotomy for an iridectomy. *L*, L^1 is a true linear section, but this is impossible to achieve. The perfect incision would be *P*, P^1, and any obliquity from this will give a section so obliquely placed as *N*, N^1 that there will be a definite and distinct shelf to

[1] Beard, Ophth. Surg., 2d ed., Philadelphia, P. Blakiston's Son & Co., pp 601 015

and the edge of the knife is turned outward very slowly, still beneath the conjunctiva, and the limbal section thus completed. This maneuver minimizes to the greatest degree the width of the posterior lip of the wound, hence assures the greatest possible aperture. The conjunctiva which now is lying upon the blade is cut as a flap by continuing the sweep of the blade upwards, but with the edge now directed well away from the eye and toward the operator. In completing the section and the flap, the knife should be turned so that the cutting edge is almost completely facing the operator. Completing the conjunctival flap in this manner makes it possible to gauge the size of the flap and cut it as is desired.

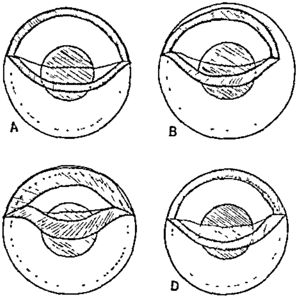


FIG. 433.—Same as Figure 432 but surface view. *A*, ideal section, *B*, section split in counterpuncture; *C*, section split at all points; *D*, counterpuncture too far forward (Ophthalmic Surgery, Beard, courtesy of P. Blakiston's Son & Co)

The size of the conjunctival flap which can be obtained depends almost wholly upon the desires of the surgeon. If a generous conjunctival flap has been cut, its upper attachment may remain unsevered, extraction then to be done beneath this bridge of conjunctiva. Many men follow this procedure routinely in that it makes sutures unnecessary. As a matter of fact its value for this reason is not concurred in. A more logical contention for the advisability of a conjunctival bridge is that such a bridge makes the subsequent removal of sutures unnecessary. In some patients this might be a factor. Any procedure, however, which hampers the ready extraction of the lens is undesirable unless it has other attributes far outweighing this hindrance. Sutures are indicated, readily introduced, and usually easily removed, and the hinged or bridge flap limits unnecessarily the extraction of the lens. It seems inconsistent to plan for a section of adequate size and immediately thereafter limit the availability of the aperture obtained by the flap unless other factors are present in the case which makes the case extraordinary and not routine. It is probable that an intact conjunctival bridge will limit vitreous loss in certain complicated cases, and it may therefore be seriously considered in the extraction of dislocated lenses.

the lip of the wound in part or in its entirety, thereby minimizing to an appreciable and oftentimes dangerous degree the available aperture which the operator has for his lens extraction. An incision which involves two-fifths of the circumference of the cornea is usually considered ideal and ample, but shelving of the corneal lip can reduce this a fourth to a third of the aperture to be utilized. To avoid splitting the cornea is Beard's briefest answer toward obtaining an aperture which is proportionate to the limbal circumference of the section. Figure 433, *A*, is diagrammatic of the face surface of the ideal incision. It should be neither corneal nor scleral, but at the junction of the cornea and the conjunctiva. The point of puncture and counter-puncture should just barely invade the conjunctiva. One can see by this diagrammatically, Figure 432 in that *P*, P^1 is at the conjunctival edge. A corneal section, while not damaging, does prevent a conjunctival flap, and the writer feels that a conjunctival flap is essential to an ideal cataract extraction. An intractable patient, an eye in enophthalmos, a narrow palpebral fissure, a shallow anterior chamber, early loss of aqueous, and hypotension of the eyeball, are all factors which complicate the incision, and it is not always possible to obtain the ideal. The truism relative to the importance of the section still stands, but the more capable the surgeon, the more likely will his operative results be good in spite of a faulty section.

The cataract knife is grasped in the right hand with the thumb on top and the first two or three fingers below, lightly balanced, inspected to be sure that the cutting edge is facing upwards, and the point is then engaged at the limbus in or at the edge of the conjunctiva 1 mm. above the horizontal meridian, with its long axis almost perpendicular to the curve of the eyeball. The line *P*, P^1 of Figure 432 is the plane of the blade and its handle. The knife is passed through the limbus, and the moment the tip appears in the anterior chamber the handle is depressed, backwards that is, moving the tip at the same time across the center of the pupil to the opposite limbus. Here again *P*, and P^1 direction is ideal; now, however, the sequence being P^1, *P*. The line of this is manifestly impossible, as one can see by looking at this drawing, but certainly it is possible to minimize the obliquity. Therefore, before the counter-puncture is made, the handle is depressed slightly more than when the blade and its point were passed across the center of the pupil. Due to the refraction of the corneal curvature the point of engagement for the counter-puncture should appear to lie in the visible cornea itself at the line limiting this visibility. The engagement will then be actually 1 mm. more posterior than that apparently seen. Engagement for counter-puncture within this point of visibility will split the cornea and narrow the aperture appreciably, while engagement posterior to that point will bring the blade into the root of the iris or even into the ciliary region, damaging these structures and resulting in considerable hæmorrhage. With the knife thus engaged in puncture and counter-puncture, the section is completed by an upward sweeping motion of the entire blade and the handle, though the tip of the blade should travel a bit faster than does the heel. After the blade has reached the upper fourth of the circumference of the limbus, the conjunctiva becomes engaged and the remaining portion of the section is completed subconjunctivally. The sectioning should be with as smooth a motion as is possible, that is, with as little sawing as the keenness of the edge of the blade will permit. The upper limbus is reached,

and the edge of the knife is turned outward very slowly, still beneath the conjunctiva, and the limbal section thus completed. This maneuver minimizes to the greatest degree the width of the posterior lip of the wound, hence assures the greatest possible aperture. The conjunctiva which now is lying upon the blade is cut as a flap by continuing the sweep of the blade upwards, but with the edge now directed well away from the eye and toward the operator. In completing the section and the flap, the knife should be turned so that the cutting edge is almost completely facing the operator. Completing the conjunctival flap in this manner makes it possible to gauge the size of the flap and cut it as is desired.

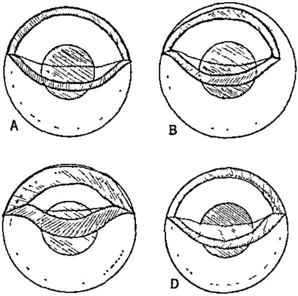


FIG. 433.—Same as Figure 432 but surface view. *A*, ideal section *B*, section split in counterpuncture; *C*, section split at all points; *D*, counterpuncture too far forward (Ophthalmic Surgery, Beard, courtesy of P. Blakiston's Son & Co)

The size of the conjunctival flap which can be obtained depends almost wholly upon the desires of the surgeon. If a generous conjunctival flap has been cut, its upper attachment may remain unsevered, extraction then to be done beneath this bridge of conjunctiva. Many men follow this procedure routinely in that it makes sutures unnecessary. As a matter of fact its value for this reason is not concurred in. A more logical contention for the advisability of a conjunctival bridge is that such a bridge makes the subsequent removal of sutures unnecessary. In some patients this might be a factor. Any procedure, however, which hampers the ready extraction of the lens is undesirable unless it has other attributes far outweighing this hindrance. Sutures are indicated, readily introduced, and usually easily removed, and the hinged or bridge flap limits unnecessarily the extraction of the lens. It seems inconsistent to plan for a section of adequate size and immediately thereafter limit the availability of the aperture obtained by the flap unless other factors are present in the case which makes the case extraordinary and not routine. It is probable that an intact conjunctival bridge will limit vitreous loss in certain complicated cases, and it may therefore be seriously considered in the extraction of dislocated lenses.

Eber[1] discussed this in detail in considering complicated cataract cases. Elschnig's recommendation[2] for this type of operation limits it to high myopia and to exophthalmos, two conditions essentially similar. Von Pflugk[3] would add to these cases of emphysema and those subject to heart attacks.[4] The writer will concur in these, but the statement must be reiterated that conjunctival sutures are a more logical and an equally sound surgical principle. The claim that the danger of vitreous prolapse is minimized by means of a conjunctival bridge is a most individual factor, and controversy relative to it is quite logical.

The formation of the conjunctival flap itself is the combination of several different factors. First, its value lies in the facility of placing the subsequent sutures, and the flap, plus these, assures an earlier sealing of the wound and reformation of the anterior chamber, minimizing thereby later iris prolapse, high degrees of astigmatism, and the formation of limbal staphylomata; it safeguards the immediate postoperative period from the minor traumatisms of excited and unruly patients by restraining the vitreous and permitting the retention of the aqueous; and it certainly is a factor in minimizing postoperative infection. After the counter-puncture has been made and the knife begins its upward sweep, a drop of aqueous may appear under the conjunctiva and balloon it out. While not desirable, in that it may be responsible for the iris falling in front of the edge of the blade, the complication does illustrate the desirability of ballooning out the conjunctiva itself with a bit of novocain routinely before the section has been started. The flap need not be large, nor is it necessary that it terminate at the 12 o'clock meridian. Many of the men routinely complete their flap slightly to one side or to the other of the vertical, though Butler felt that this had a tendency to make the subsequent astigmatism oblique. Certain cases, as one-eyed individuals, those with high myopia and with exophthalmos, individuals with emphysema and asthma, and those subject to heart attacks, nervous and insane patients, and those in general who may be unruly or have a stormy convalescence, most certainly need a conjunctival flap. Because of this, it is quite permissible to prepare the flap before the section has been made; even if necessary to make the section after such a flap has been prepared with a keratome, and then to enlarge it at its two extremities with a pair of scissors.

Any incision which appears too short for the extraction of the lens under question should be lengthened before the extraction is attempted by clean cut snips of sharp pointed but rather stout scissors. Figure 434 illustrates the point of puncture and counter-puncture as viewed from the front, and shows the position of the knife in its upward course. The conjunctival flap is in process of formation at the point of counter-puncture. Figure 434, *C*, shows the flap being completed, the knife now appearing narrow because of the perspective of the edge, which has been turned slightly forward. Figure 434, *D*, shows the completion of the section and the traction of the flap in a case where a pre-prepared flap had been thought advisable. As previously stated, a keratome may be used to start the incision in these cases if it is thought advisable.

[1] Am Jour. Ophth., Ser. 2, vol. 13, February, 1929.
[2] Klin. Monatsbl. f. Augenh., 66, 930, 1921.
[3] Klin Monatsbl f. Augenh., 70, 767, 1923.
[4] Clapp, Cataract, Etiology and Treatment, Lea & Febiger, p. 170, 1934.

When the iris falls in front of the knife while making a corneal section, one must proceed with the section regardless of this complication. If a clean iridectomy is made thereby, well and good; if not, the iridectomy must be made thereafter as one best can, depending upon the amount of trauma to the iris. Knapp found that if one halts the progress of the knife for a moment and presses upon the cornea behind the back of the knife with a moistened sponge or applicator, it is frequently possible to depress the iris and the lens diaphragm sufficiently so that the sphincter of the iris will pass beneath the edge of the knife and make possible a completed incision without actual damage to the iris.

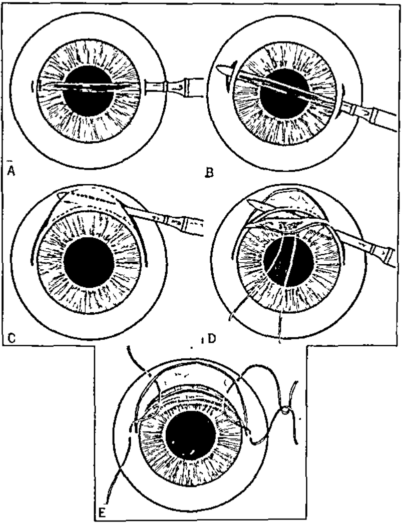


FIG. 431.—*A–D*, the technique of a cataract incision *E*, with a van Lint flap.

Many modifications of the cataract incision are in the literature. Some of them complicate the surgery and offer no advantages. Others, however, do have an advantage for individual cases. These techniques, however, are individual and their discussion essentially monographic. To recapitulate, the essentials of a satisfactory cataract section in their order of importance, are: (1) satisfactory fixation of the eyeball; (2) puncture and counter-

puncture, both lying just within the vascular zone and just without the clear corneal stroma; (3) as close an approach to the line P, P^1 and P^1, P (Fig. 432) as it is possible to get; (4) a steady cutting motion is made with the blade from the counter-puncture without any halt or pause, completing the major portion of the incision in one movement; (5) a sharp knife is necessary so that sawing movements are minimized; (6) care in keeping the knife parallel to the plane of the iris and advancing it upward without permitting any backward pressure toward the sclera; (7) an incision, the lips of which are of an equal width throughout; (8) absence of shelving above, that is, a rigid continuation of satisfactory position of puncture and counter-puncture throughout the length of the circumferential section; and (9) a satisfactory flap.

The complications of an extraction in part rest with these above, *i. e.*, essentials 1 to 9. Most of them could be prevented if all conditions had been ideal at the time of the operation. The position of the counter-puncture, while usually one of deliberate selection, may be modified by an unruly patient and by a shallow anterior chamber. Unsatisfactory fixation is probably one of the most common causes for difficulty with the counter-puncture. Occasionally the section terminates in the cornea proper, and no conjunctival flap is obtained except perhaps one or two tags or dog ears of conjunctiva at the extremes of the incision. This may result from a sudden upward movement of the patient's eye during the section, or develop from too extensive an injection of anesthetic into the conjunctiva, thus obscuring the landmarks. Unusual hæmorrhage will occur if the edge of the knife is directed posteriorly toward the plane of the iris in that its penetration will be too deep. Collapse of the anterior chamber from loss of the aqueous may make it necessary at times to complete the section within the cornea. In shallow anterior chambers and in cases with premature loss of the aqueous, the iris will fall in front of the knife, making all degrees of an iridectomy from a complete coloboma to a bare peripheral iridotomy or notching of the root of the iris. While this is not of grave consequence, still a sharp hæmorrhage may occur and obscure the field of operation; also it may result in a complete iridectomy larger than that which would be otherwise necessary, or even compel an iridectomy in a case which logically could have been an extraction through a round pupil combined with or without a small peripheral iridotomy. A conjunctival flap is not always achieved, though if any tags are present for suturing, these will suffice. Failing these, it is perhaps better to proceed with the extraction rather than invite a catastrophe because of the time which it would take to prepare a satisfactory sliding flap. Still, certain cases appear wherein the better part of discretion will be to halt the extraction for a few minutes and prepare first a sliding van Lint flap. The sutures are to be introduced immediately, ready for instant postextraction tying. Figure 434, *E*, illustrates this.

Every so often an operator suddenly discovers that the knife has been introduced for the corneo-scleral incision with its cutting edge upside down. To prevent this the knife should be inspected just before it is introduced. If the surgeon's attention is then diverted by some happening or for some other reason, there is a possibility that this misfortune will occur. When it is present one is faced with the necessity for immediate action. If it has been noticed before the counterpuncture has been made, the knife may be

withdrawn and reintroduced, though there is danger of losing the anterior chamber thereby. If the counterpuncture has already been made, withdrawing the knife would probably result in the loss of so much aqueous that it would be necessary to postpone the operation, and the necessity for this could be embarrassing to the surgeon. Various men have spoken of a quick turning of the knife in the incision. It should not be done before the counterpuncture is made, and if it is done the operator should be sure that the cutting edge is turned in an up-and-out 180 degrees arc, so that the cutting edge will not sweep across the capsule of the lens. There are two other alternatives, to withdraw the knife wholly and complete the section with a pair of sharp scissors, or to continue with the section downward and proceed with the lens extraction through the inferior limbus. A scissors cut, even when most skillfully done and with satisfactory scissors, does not give as smooth a cicatrix as does the clean cut of the Graefe knife. On the other hand, extraction through the inferior limbus should proceed uneventfully. (See section on Cataract Extract Following Trephining Operations.)

Conjunctival Sutures.—A consideration of the necessity for sutures could not exist anywhere in surgery except with the ophthalmologist. In general surgery, even the smallest incision will be surgically closed after the operator has achieved the purpose for which he is operating. It is equally necessary in cataract extraction, for so frequently the integrity of the eyeball and the patient's subsequent vision depend upon firm and early union of the section. Various forms of conjunctival sutures have been considered. Theoretically the ideal one is that which is easily introduced, one which will not interfere with the extraction of the lens and which, after the extraction, is easily and rapidly secured. A dictum of the abdominal surgeon is to "get in and then to get out," and the same applies to a cataract operation. Hence, the sutures which can be tied in part before the extraction are to be desired. The running suture with cut, untied ends so satisfactory in glaucoma surgery is not applicable here because, if it is introduced before the extraction, its loops, even if drawn to the side, will interfere with the extraction, and the practice of introducing the sutures after the extraction is to be avoided. Corneal sutures are permissible if an unsatisfactory flap has been obtained, or if there is a tendency toward gaping of the wound.

Wolff and McLeod's[1] indications for suturing the wound, especially with the intra-capsular type of extraction, are:

> (1) The wound should be closed securely and accurately as the most important requirement for preventing postoperative vitreous prolapse, and thereby at the same time securing rapid healing; (2) closure must be rapid, so that one may be able to seal the incision within from five to fifteen seconds after the lens has been delivered. This is important if vitreous presents behind the lens and is perhaps the only point in a cataract extraction where speed is absolutely essential. (3) The suture should be placed before the incision is made, and, therefore, must be placed in such a way as to allow the passage of the knife.

(The author cannot agree wholly with this; it implies complicated insertion of sutures, and demands a preliminary conjunctival flap or the less satisfactory corneo-conjunctival sutures. Nothing should be permitted to complicate or interfere in any way with a satisfactory corneal section. Conjunctival sutures should be placed after the corneo-scleral incision and not

[1] Arch Ophth., vol 8, August, 1932.

before. Vitreous prolapse is a rare complication before the lens extraction, and the presence of sutures at this time, *i. e.*, before the lens extraction, would not in any way modify the subsequent course of the extraction. Wolff and McLeod are correct in stating that placing the sutures after the extraction while vitreous is oozing, or presenting, can result only in further loss of vitreous. The fact that they use the Verhoeff corneo-sclero-conjunctival suture almost wholly explains their recommendation.) The conjunctival flap should be large enough to cover the entire incision, giving a truly surgical closure, tending to prevent infection of the wound and covering any small iris prolapse as soon as it occurs. No single suture can absolutely insure against prolapse; and secure closure must be possible especially if the cataract is extracted within a few weeks after a preliminary iridectomy.

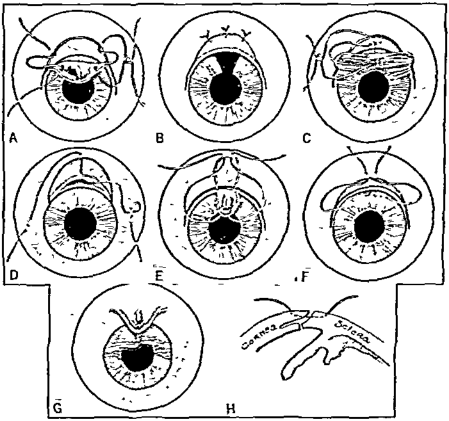


FIG. 435.—Cataract sutures. *A* and *B*, simple sutures introduced before extraction, tied thereafter. *C*, Kalt's suture. *D*, Berens' suture. *E*, *F* and *G*, Verhoeff's sutures; *H*, Walker's suture.

Birch-Hirschfeld[1] analyzed 1320 of his own cataract cases. The first 777 were done without sutures, the last 543 were operated with sutures. In the second series the number of patients with better vision was higher, postoperative astigmatisms less, and the number of needlings fewer. There were 31.7 per cent of needlings in the first series and 12.1 per cent in the second. Loss of vitreous was present in the first series in 7 per cent of cases and in the second in only 3.5 per cent. Rupture of the wound occurred in

[1] Ztschr. f. Augenh., April, 1931.

the first series in 4.1 per cent of cases, and in the second in only 1.1 per cent. Postoperative infections developed in the first in 0.64 per cent of instances, and in the second series in 0.37 per cent of cases. Expulsive hæmorrhage occurred twice in the first series and not at all in the second.

The sutures should be introduced as soon as the section has been completed. Figure 435 illustrates these sutures. If the circumference of the flap is divided into thirds, the two sutures placed should be at the junction of the outer and middle thirds and the inner and middle thirds. A small non-locking needle holder is best for the introduction of these sutures. Verhoeff's new needle holder[1] is especially satisfactory for the introduction of sutures in cataract surgery because of the firmness with which it holds the needles and at the same time the ease with which the needle holder and the needle can be manipulated. The author's needle holder for cataract surgery (Fig. 10) has seemed to be quite satisfactory. One must be able to release the needles readily and promptly if the patient should move the eyeball, and if there is a lock on the needle holder, it will be difficult to release the needles smoothly. As soon as the two sutures are in place, the first turn of an ordinary square knot should be loosely tied in each. A broad iris spatula can then be placed between the loose knot and the loop of the suture (between the flap and the conjunctival edge) and these two drawn well to the side so that they will not interfere with the subsequent extraction. The moistened wet end of a sponge will assist in placing them at the inner and outer canthal angles. As soon as the extraction has been completed, before anything else is done, even irrigation of the anterior chamber or reposition of the pillars of the iris, these two sutures are tied and their ends cut short. After that, the necessary toilet of the anterior chamber and of the wound can be carried out with a minimal danger of complications. A third suture, and even further additional sutures, can be placed thereafter, depending on the size of the flap, the age of the patient, and upon other circumstances which are individual in any one case.

If the section has been corneal, it is perfectly proper to use Kalt's corneal-episcleral suture. A special needle, however, should be used for this, *i. e.*, the very fine Kalt needles which have a sharp point but a round body. It is threaded with twisted silk which has been well anointed with bone wax or with sterile petrolatum. It is first passed through the superficial layers of the cornea about 1 mm. from the edge of the cut, then passed above in the episcleral tissue also 1 mm. from the edge of the cut emerging through the conjunctiva, including 2 or 3 mm. of this. Figure 435, *C*, illustrates this. This suture is tied in a single loose knot and the two loops drawn to the side for the extraction. These corneal sutures should be removed a bit sooner than the conjunctival sutures, though they often slough out a bit earlier than the conjunctival sutures. These will release spontaneously from the sixth to the eighth day, while the conjunctival sutures will take from four to six days longer if they have not been removed before that time. Nos. 8-0 and 6-0 oiled sutures with fine *'a-traumatic'* needles attached are very satisfactory for all corneal incisions.

The new corneal-scleral suture described by McLean[2] seems to be ideal. Wood in discussing this with the author felt that it was equally simple to introduce considering all other sutures, that it did not complicate the sub-

[1] Arch. Ophth., vol. 15, January, 1936.
[2] Personal communication.

sequent corneal section, and that it did close the operative wound firmly, without danger of inversion, and with maximum assurance to the operator and the patient. The technique as presented by McLean[1] follows herewith.

A small conjunctival flap is dissected down to the limbus around the entire upper half of the eye. At the base of this flap, a small slot is made with a Lundsgaard knife, Figure 436, *A* and *B*, about one-half through toward the anterior chamber. A cataract knife, keratome or sharp scalpel could be used for the same purpose. A fine black silk suture on Kalt's corneal needle is then run through the base of the

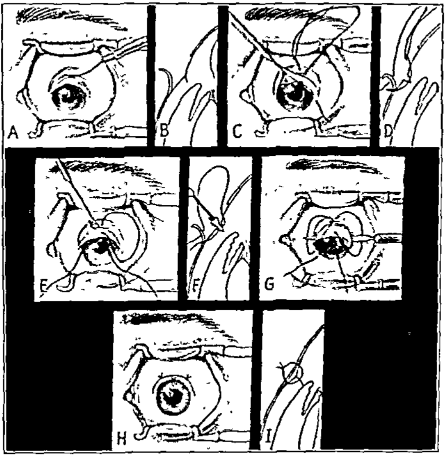


FIG 436 —McLean's corneal-scleral suture.

conjunctiva, reversed, and then run through the base of the conjunctival flap, Figure 436, *C* and *D*, including the scleral lips of the slot. The suture is thus placed so that when it is later tied it will bring the lips of the wound back to their original position before the eye is opened The suture is then pulled out of the slot with a blunt iris hook Figure 436, *E* and *F*, and the loops laid aside to give room for the cataract knife, as in *G*. A section is made under the flap with the knife seeing whether it emerges at the base of the slot between the arms of the suture Such a section is not as difficult as it sounds, and has been successfully performed by inexperienced house officers on first trial. Traction is permitted in the usual way and the suture pulled taut and tied at the end of the operation. See Figure 436, *H* and *I*. If irrigation or extensive toilet of the wound is necessary, the suture may be tied before, making these maneuvers much safer. Further sutures may be placed in

[1] Arch. Ophth., vol. 23, March, 1940.

the edges of the conjunctival flap if this seems advisable to hold it in place, but firm closure of the wound is maintained by the corneal suture. The suture is not at all irritating, and can be left in place for some time. It has been the general practice to remove these sutures between ten and twelve days.

The more complicated scleral flap incisions and sutures may have a place in individual cases, but in general, the difficulty of arranging them is not compensated by a proportionate degree of safety. Walker's split guarded cataract incision with suture is perhaps the most logical of these, but it is certainly not necessary for routine extractions. A primary furrow is cut with a cataract knife halfway through the cornea above the limbus slightly posterior to the root of the iris. From this a scleral pocket is made downward with a keratome and a suture placed from the upper to the lower scleral lips. This suture is then drawn to the side and the corneal incision completed.

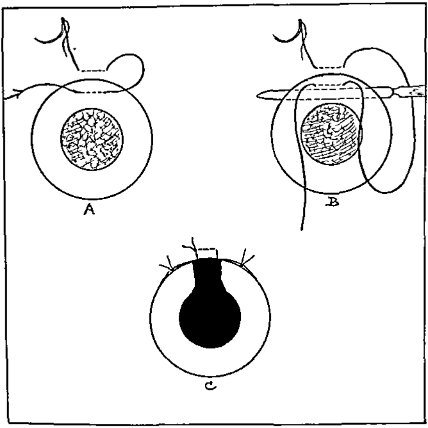


FIG 437 —The Stallard suture *A*, in position *B*, position of the suture and the loops during the section. *C*, suture tied with additional conjunctival suture (these latter are optional).

Hilding[1] showed so conclusively, in his experimental work on the mechanisms connected with iris prolapse, that a corneo-scleral suture was of the greatest value in preventing iris prolapse. The efficiency of this type of suture was far superior to any type of conjunctival suture, or of conjunctival flap. These findings of Hilding are to be seriously considered.

[1] Trans. Am Acad. Ophth. and Otolaryn , 1938.

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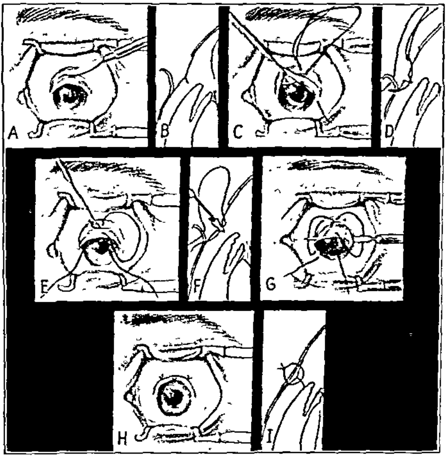

Fig. 436.—McLean's corneal-scleral suture.

conjunctiva, reversed, and then run through the base of the conjunctival flap, Figure 436, *C* and *D*, including the scleral lips of the slot. The suture is thus placed so that when it is later tied it will bring the lips of the wound back to their original position before the eye is opened. The suture is then pulled out of the slot with a blunt iris hook. Figure 436, *E* and *F*, and the loops laid aside to give room for the cataract knife, as in *G*. A section is made under the flap with the knife seeing whether it emerges at the base of the slot between the arms of the suture. Such a section is not as difficult as it sounds, and has been successfully performed by inexperienced house officers on first trial. Traction is permitted in the usual way and the suture pulled taut and tied at the end of the operation. See Figure 436, *H* and *I*. If irrigation or extensive toilet of the wound is necessary, the suture may be tied before, making these maneuvers much safer. Further sutures may be placed in

[1] Arch. Ophth., vol 23, March, 1940

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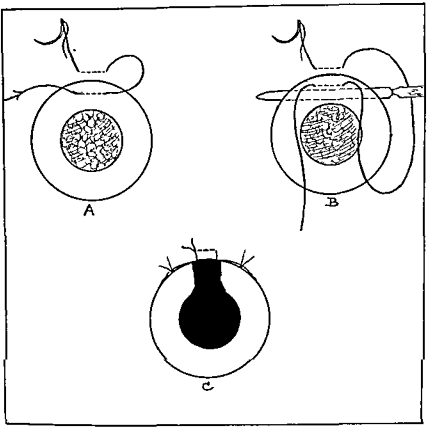

FIG. 437.—The Stallard suture *A*, in position. *B*, position of the suture and the loops during the section. *C*, suture tied with additional conjunctival suture (these latter are optional).

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[1] Trans Am. Acad. Ophth. and Otolaryn., 1938.

The Stallard[1] corneo-scleral suture has been the choice, more recently, of many operators, including the writer. The suture, threaded upon a non-traumatic needle with waxed No. 6-0 black silk, is passed through the corneal stroma (in depth for one-half of its thickness) less than 2 mm. from the limbus, tangential to it, at 12 o'clock, for a distance of 2 to 3 mm., this lying equally upon both sides of the 12 o'clock corneal meridian. It is then passed through the conjunctival and the episcleral tissue for the same distance, parallel to the corneal insertion and at the same distance from the limbus. The needle is cut from the suture, the loop of the silk moved well up and to the side, and the corneal-scleral section made with no great regard for a conjunctival flap, the knife emerging between the corneal and the scleral insertions. After the extraction, the suture is pulled up and tied with a simple double knot. The knot must be up and away from the corneal surface. It can be removed six to eight days postoperatively. See Figure 437 for description of the insertion, the position of loop during the section and the suture when tied.

Berens' suture[2] is rather satisfactory for the untied ones, and is recommended especially for cataract extractions. He first makes a 3 mm. conjunctival flap above, extending this on the sides to the limbus. Four millimeters of conjunctiva are then picked up with a suture at either the outer or the inner canthus. This suture then includes the two lips of the conjunctival flap, and from there it is carried to the opposite canthal angle and introduced through a similar amount of conjunctiva. This end is secured through reintroduction into the conjunctiva so that it forms a loop there (Fig. 435, *D*). The suture which appears between the lips of the conjunctival flap is drawn to the side for the extraction. After the operation is completed the two ends are drawn taut and cut, so that both free ends protrude from the palpebral fissure.

Several men, as Maddox, Wolff, and Derby, turned down a very small conjunctival flap at the 12 o'clock meridian before the corneal section was made, then mattressed a suture through this to the lip of the conjunctival defect above, and obtained their closure in this manner. Verhoeff's modification of the Kalt suture[3] has been used several times by the author, when circumstances made a *post-incision* corneal suture necessary, with universal satisfaction.

After the corneo-scleral section has been completed, one end of a double-armed fine silk suture armed with corneal needles is passed through the superficial layers of the cornea 1.5 mm. from the lip of the corneal wound. The two needles are then passed through the conjunctiva, one of the sutures 2 mm. from the edge of the conjunctiva and the other 3 mm. from the same edge. The loop of this mattress suture is drawn to the side before the extraction and after the extraction has been completed the suture is tied down. As a result of this suture the corneo-scleral incision line is closed by a small tongue of conjunctiva drawn down, as the suture is tied, closing the incision line firmly as in Figure 435, *G*.

This technique is his modification of an earlier method which he had described some time before that.[4] He states that this latter modification eliminates any danger of cutting the suture at the time of making the corneal section and gives the effect of a sliding conjunctival flap.

1 Brit. Jour. Ophth., May, 1938.
2 Am. Jour. Ophth., 8, 112, 1925.
3 Trans. Am. Ophth. Soc., 25, 48, 1927.
4 Clapp, Cataract, Etiology and Treatment, Lea & Febiger, p. 190, 1934.

IRIDECTOMY—IRIDOTOMY—THE ROUND PUPIL

Much has been discussed relative to these. Recapitulation follows or accompanies each separate technique. Pages 604–606, under surgical pathology, contains a detailed description for and against the different possibilities.

CAPSULOTOMY EXTRACTION WITH IRIDECTOMY

In general, capsulotomy extraction with iridectomy is most applicable to those cataracts of early adult life, before the age of forty-five and fifty years, in which a linear extraction cannot be done, or one in which an intra-capsular extraction is impossible because of the age of the patient. The more immature the state of the cataract present, however, the more is it, desirable to obtain if possible an intra-capsular extraction. In addition a lens extraction in the extremely aged, especially if the lens is quite mature, is perhaps best done by means of a capsulotomy extraction with iridectomy, so that all possible complications are reduced to the barest minimum. In addition, all types of lenses, complicata, senile and presenile, nuclear and cortical, with synechiæ which cannot be released after the corneo-scleral incision, must be removed by the capsulotomy method. Further, a simple extraction by the capsulotomy method (one being done through a round pupil) will have to be converted into one with an iridectomy, (that is, combined extraction) if prolapse of the iris or the vitreous develops, or if one feels that the postoperative convalescence of the patient is best safe-guarded by an iridectomy.

After the introduction of the bridle suture and the lid sutures, the corneo-scleral incision is made as has been outlined. The conjunctival sutures or the corneal suture is then introduced and the loops of these drawn to the side. The bleeding from the section should be stopped by sponging and adrenalin if necessary, and the iris replaced if it has been deformed by the section or cut in part with the cataract knife. An iridectomy needs to be, under ordinary circumstances, only sufficiently large to break the sphincter unless other factors are present in the case. The iris forceps are then introduced into the wound with the left hand usually, the iris grasped exactly at the sphincter and withdrawn a sufficient amount from the corneo-scleral wound, so that the black uveal surface is exposed. The iridectomy is made with iris scissors by holding the blades parallel with the vertical meridian of the cornea and not tangentially to the limbus. One must be certain that any sutures introduced are not being cut, and further, that one is not cutting upon the conjunctiva nor upon the delicate tips of the iris forceps. The iris which is withdrawn by the forceps should be held in close contact to the scleral lip of the wound and not held free from the scleral lip. This maneuver guards against a more or less complete iridodialysis if the patient should move his eye before the iridectomy has been completed. The iris should be cut with a single clean snip of the scissors, and the hand holding the iris and iris forceps should not be moved from the eye until the operator is certain that the iris has been cut. If this is not done, sooner or later one will see a complete iridodialysis occur as a result of an incomplete sectioning of the iris and a too abrupt, jerky removal of the iris forceps, with the contained iris, from the lips of the wound.

After the iridectomy, the pillars should be immediately replaced with an

iris spatula, and if there is any blood in the anterior chamber, this removed by gentle irrigation. The eyeball is then fixed with forceps, at six o'clock upon the limbus, and rotated downward, and the closed toothed capsule forceps introduced through the incision along the path of the coloboma of the iridectomy to the mid-point of the lens, that is to the center of the pupillary aperture or even slightly below it. The blades of the capsule forceps are permitted to open a distance of 3 to 4 mm., depending upon the dilation of the iris, thrust gently but firmly into the capsule, the blades closed, and the large piece of anterior capsule engaged between these blades, torn from the lens by a to-and-fro rocking movement. At the same time this side-to-side movement of the capsule forceps is continued while the closed blades of the forceps are withdrawn from the eye.

The lens is then expressed by one of several different maneuvers, all of which have various points in their favor and seem best adapted to the different and varying circumstances present. In general, the posterior lips of the wound are depressed very slightly by a loop, a broad spatula, or a

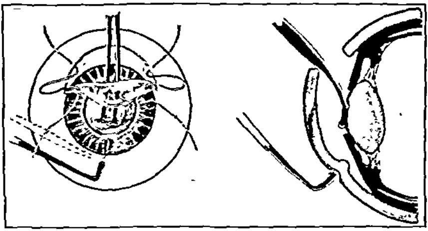

FIG 438 —Capsulotomy and extraction.

spoon. *At the same time pressure is applied, directed posteriorly, by the* blunt end of a lens hook or the curved loop of a large strabismus hook or by pressure of the thumb. The pressure applied in this way causes the solid part of the lens to tip forward through the capsulotomy opening and to rise out of its capsule toward the corneo-scleral incision line. As this occurs, the expression hook is moved away from the limbus onto the cornea proper, staying directly behind the heel of the lens. The oncoming equator of the lens appears in the corneo-scleral incision, and as the extraction progresses, the pressure below can be augmented by the loop or the lens spoon which has been depressing the posterior lip so that the lens slides out of the incision, and up the spoon, as if it were ascending an inclined plane. *As soon as half of the lens has passed through the incision the pressure upon* the cornea should be decreased most decidedly and only a sufficient amount used to continue the steady forward and upward movement of the lens. At this time the loop or the spoon are of greatest assistance in completing the extraction by elevating the lens from behind. As a result, if the maneuver is well carried out, the lens will actually follow the curve of the sclera

called our attention to the value of digital pressure against the eyeball deep in the inferior cul-de-sac to elevate a partially dislocated lens so that it will again present in the pupillary aperture or in the coloboma of the iridectomy.

CAPSULOTOMY EXTRACTION WITH A ROUND PUPIL

Capsulotomy extraction without iridectomy but with a peripheral iridotomy proceeds in a rather similar method. The pupil should be well dilated, and in making the corneal section one must be doubly careful, and, if it is at all possible, prevent the iris from falling in front of the blade of the knife. After the section has been completed and the sutures introduced, the iris sphincter is carefully replaced to its normal position. If it remains quiet without any tendency to prolapse, the operator may proceed immediately with the capsulotomy and the extraction, hoping to obtain a simple extraction of the lens. If the extraction has been completed through this pupil without the loss of vitreous, and if the iris can be normally replaced with a round pupil after the extraction and the necessary irrigation, the toilet of the wound may then be completed, additional sutures placed, and the eye dressed without an iridotomy. If, however, there has been a vitreous prolapse present, especially in the presence of a normal vitreous, then a complete iridectomy should be done some time after the first two sutures have been tied. If a large flap is present, a third central suture may be placed and tied before the iridectomy itself has been performed. Should there by any tendency to iris prolapse or any difficulty whatsoever in replacing the iris so that a round pupil is obtained, but without vitreous prolapse, then one should do a peripheral iridectomy to permit free communication between the posterior and the anterior chamber at the angle, thereby guarding against a subsequent postoperative iris prolapse.

The Hess iris forceps is introduced into the wound as close to the root of the iris as the section will permit, the iris grasped with a tiny bite of the forceps, its tips just barely withdrawn, and the iris between the tips cut free, making a round, slightly oval, or triangular peripheral iridectomy. After this has been done, one should have no difficulty in restoring the intact pupillary margin to a normal round shape. In general, the author prefers a peripheral iridotomy prior to the lens extraction and seldom if ever sees any indication for the simple extraction. Naturally cases may present themselves wherein the simple extraction does seem desirable, but a minute peripheral iridotomy or iridectomy is so satisfactory in safeguarding subsequent iris prolapse, and in so far as the patient is concerned, the end-results are equally perfect. With this in mind, it seems the iridotomy is best done as soon as the sutures have been introduced.

Employing another method, the lips of the wound are made to gape very slightly by traction upon the conjunctival flap. The root of the iris which appears in the incision is sponged free of blood by an assistant with a quick application with the tip of a moistened sponge and then incised at the root with a Ziegler knife needle, making an incision 2 or 3 mm. in length, as in Figure 439, or the iris is actually grasped by very delicate iris forceps (as using the Hess iris forceps), and a triangular iridotomy of that portion of the iris imbedded within the tips of the forceps is made *ab interno*, that is, with the blades of the Barraquer or de Wecker iris scissors actually within the lips of the wound. Any traction upon the iris at this time will result

in an unnecessarily large iridotomy. If the corneal section has been made improperly so that there is an overhanging shelf of cornea, or of sclera, forming the posterior lip of the wound, then it may be necessary to actually draw the iris downward with the forceps from behind this shelf before the iridotomy can be done. Under these circumstances one should not try to do an iridotomy with the knife needle because the incision will not be at the root of the iris and, hence, of no functional value. If the knife needle is to be used for the iridotomy, the operator must be careful that he does not plunge it into the iris too deeply, thereby injuring the underlying suspensory *ligament*. This will result *in an early prolapse of the vitreous*, in fact, vitreous may present as soon as pressure is applied to the cornea for the subsequent extraction.

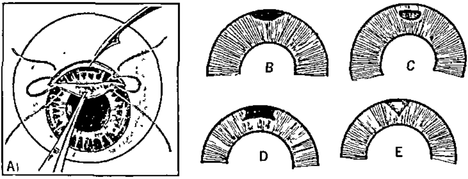

Fig 439.—Cataract peripheral iridotomy *A*, with Ziegler knife needle, *B*, the result *C* and *D*, iridotomies, *ab interno*, *E*, peripheral iridectomy with scissors and Hess forceps

The satisfaction the patient derives from a round pupil is well worth the attempt to do this surgery whenever possible, but attention must be paid to the iridotomy; otherwise a later iris prolapse will so commonly occur, that the operator may discontinue wholly this valuable method because of embarrassment and vexation. Figure 439, *A*, illustrates the maneuver for making the peripheral iridotomy with a knife needle, *B*, the type of iridotomy one should obtain thereby, *C* and *D* are the usual forms of iridotomy and iridectomy one obtains after the cataract extraction, while *E* is the usual peripheral iridectomy seen when this is done with Hess forceps and with scissors, before the lens extraction.

A. Fuchs[1] may be quoted as follows:

> The operation with a round pupil is regarded as the better for extraction of cataract, since it is easier to control by the roundness of the pupil the reposition of the iris. Incarceration of the iris is certainly the cause of most complications, although every incarceration does not lead to complications. Cicatricial ectasiæ of the iris, chronic iritis, sympathetic ophthalmia, fistulization, increased pressure and migration of epithelium are all caused by it. Reposition of the iris is likewise much easier when the pupil is round It is important for the reposition that the incision should not be made too near the periphery. The incision should come out above, just back of the limbus; then the wound does not bleed, and it is easy to strip the iris back. But if the iris is strongly incarcerated, an event which is due as a rule to the fact that the incision was made too far posteriorly, one can occasionally (the greatest caution is indicated) grasp the iris in the region of the sphincter with the iris forceps and draw it toward the middle of the pupil. Great care is needed in

[1] Arch. Ophth., vol 16, September, 1936

order not to tear away the iris from its root, and one must not, therefore, pull it too far from its insertion. It should be understood that one does not resort to this maneuver unless all other means have been tried in vain. In extraction with a round pupil incarceration of the capsule is also probably much more rare than in total iridectomy, since with the stripping back of the iris the invisible capsule also is removed from the incision.

At the same time, Fuchs also calls attention to the fact that if any scraps of pigment appear under the conjunctival flap after a cataract operation they should be scrupulously removed by raising the conjunctival flap with the forceps and stroking the pigment away with the spatula. Sometimes such particles of pigment may be carried through the cut toward the iris and may give rise to fistulization and imperfect closure of the incision.

During the process of extracting the lens through the intact sphincter, there are a few precautions which must be carried out to prevent complications and to achieve a wholly satisfactory extraction. The capsulotomy should be as large as is possible. As the capsule forceps are being withdrawn from the eye one should be careful not to drag the teeth of the forceps across the iris, thereby injuring it or perhaps even prolapsing it. The pressure applied to the limbus below need not be assisted by the depression of the posterior lip of the wound until the iris begins to rise or to bulge with the oncoming lens. Then it is important that help be given through judicious use of the loop or the spoon. The iris may be coaxed very gently over the bulging superior equator of the lens as it appears between the lips of the incision, so that too much stretching of the iris does not occur. In discussing intra-capsular extractions (see page 641), this maneuver is even more important than in the consideration of capsulotomy extractions. In a capsulotomy extraction with an intact pupil, cortex masses are not as easily removed from the anterior chamber as they are when a complete iridectomy has been done. For this reason stroking the cornea, with the convexity of a spoon, may be necessary to dislodge and remove some of the larger fragments.

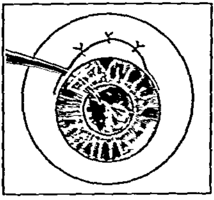

Fig. 440.—Capsule extraction with smooth untoothed forceps.

In all forms of capsulotomy extraction, regardless of whether or not a complete iridectomy has been done, one frequently sees a relatively clear and black pupil with the exception of a rather dense fringe of capsule rimming the position of the capsulotomy. If the capsule has not been displaced, itself, and the capsulotomy is quite central, the necessity for any subsequent surgery is minimized decidedly. If, however, the capsule is quite dense, and if so displaced that a later discission will probably be necessary, one may attempt an immediate capsulotomy. It is contraindicated if vitreous prolapse has already occurred. After the last suture has been tied, its ends cut and the iris replaced, one may pass a smooth untoothed capsule forceps across the iris into the pupillary aperture, and gently but firmly grasp the densest part of the capsule available, as seen in Figure 440. The capsule forceps are then withdrawn with a constant

to-and-fro movement, removing at times the entire sac of the capsule, at other times removing only a more or less greater portion of it. The hyaloid should not be broken in doing this, and to prevent this, the forceps should be introduced on its flat surface and kept in that manner at all times if possible. The fact that the forceps is introduced after the sutures have been tied limits, fortunately, too wide an opening of the blades so that the lower blade cannot break the hyaloid by an uncontrolled downward motion. If the forceps are introduced in the same manner as iris forceps, one must be careful that the tip of the forceps does not dig into the hyaloid, which is at this time above the level of the plane of the pupillary aperture. The maneuver is worth trying in many cases, for if successful it will obviate a later discission.

INTRA-CAPSULAR LENS EXTRACTION

In considering the intra-capsular lens extraction there are a number of various techniques which are of importance. The history of them and of their development is filled with research and with painstaking work, and is replete with names, past and present, of many eminent ophthalmologists. Consideration of their history should be welcome there is no doubt, but it has been covered repeatedly and in a greater detail than space will permit here.

Goldsmith[1] has recently presented a most extensive study on the anatomy of the lens and through anatomical preparations an analysis of the principles involved in intra-capsular extraction. Several of the points applicable to this section from his article are as follows. He found that tumbling when coupled with external pressure, that is, single point, horizontal curvilinear applications over the scleral surface, was found to produce the greatest number of ruptured zonular bundles with a subminimal amount of trauma. This seems to suggest that this procedure is the one of choice in approaching an intra-capsular extraction. Further, his microscopic and gross studies seem to demonstrate the complete independence of the suspensory ligament from the hyloid membrane at the anterior border layer of the vitreous. As Goldsmith said, "A keen understanding of the essential features of the external and internal dynamics permit a more intelligent approach to intra-capsular cataract extraction."

The techniques to be considered of an intra-capsular extraction are multiple; first those without the assistance of capsule forceps (as the Kalt, the Verhoeff, the Elschnig and the Arruga, in that these four types of forceps cover the major considerations); this technique is properly called or considered the Smith-Indian method of lens extraction. The second is a combination of one of the above forceps with the use of properly applied extra-ocular pressure. This is, in general, the technique of Stanculeanu. Even this, however, may be subdivided into two further parts, in that one group of operators continues with the delivery of the lens after its dislocation by maintaining their grasp of the capsule, removing the lens from the eye thus; while a second group dislocates the lens with capsule forceps and with hook perhaps, but express it (according to Knapp's technique[2]) from the anterior chamber only after the hold of the capsule forceps has been released. The third to be considered is that method wherein a loop or a

[1] Arch. Ophth., vol 29, No 3, March, 1943
[2] Knapp, Arch Ophth, 44, 1, 1915.

degrees. This tumbling, therefore, results in the presentation of the lower pole of the lens first in the corneo-scleral incision. At the same time the lens acts as an effective cork against prolapse of the vitreous. This effect will be lost, however, unless the pressure which is being applied is continued without intermittent relaxation and application. Figure 441[1] illustrates this: *A*, the direction of the pressure at the start; this is then changed by continued tilting so that the hook is directed down toward the ciliary ridge; *B*, the continuation of the pressure, its change in direction, and the cornea is now being tucked, as it were, behind the lens; *C* shows the completion of the tumbling and the intra-capsular extraction.

At the start of the delivery when the pressure is first applied, the zonula may break above, causing the superior pole of the lens to advance into the wound as in *D*, that is, the lens has not tumbled and is being expressed in an upright manner. This will always occur if desired when the pressure is applied continuously at the limbus directly posterior, as Fisher states, toward the optic nerve, "pushing the lower ends of the lens backward, tipping the upper end forward, breaking the zonula above and causing the lens to advance and engage in the wound." In such instances the completion of the extraction is essentially the same as in *C* herein, except that the lens is passing through the corneo-scleral wound at all times, with its narrowest diameter presenting rather than with its broadest diameter presenting, even though it is only for a brief moment as in the tumbling procedure. In the former of the two, the incision must gape considerably more than in the latter, but the close approximation of the cornea to the side of the oncoming lens restrains the vitreous well. Hence, in spite of the "breech" presentation of the lens, the incidence of vitreous prolapse is not increased. When the lens is leaving the eye in the upright position, the cornea does not gape as much, but equally true, the cornea is not as closely applied to the lens as when it tumbles, and this somewhat inadequate corking of the corneo-scleral aperture may permit vitreous to prolapse from above because of the primary zonular rupture there. An upright delivery is not as satisfactory as the tumbling delivery, and when it occurs it makes necessary a loop extraction to complete the operation.

The important manipulations of Smith's technique as presented by Mendig[2] are as follows:

> The knee of the hook is applied to the sclera well down in the inferior fornix, the ball of the hook touching the globe behind the edge of the lens. Smith's broad spatula is held with its convex surface against the posterior lip of the section. Pressure now is made with the spatula against the cornea over the section and with the hook—both knee and ball—toward the center of the globe. Slowly the hook is advanced toward the sclero-corneal margin. The ridge of the lens is reached, the lens rises. The pressure on the hook is decreased: its ball is raised over the conjunctival roll. The spatula is removed, and the hook, continuing its course, tucks the cornea under the lens. The lens, still adherent along its upper border, is gently raked off. Speed is not indicated; the globe and its contents are absolutely under control, and all progress subject to the will of the operator. It is practically impossible to dislocate the lens above or to express the vitreous in delivery.

In right handed individuals, the forceps should be applied with the right hand, and the hook with the left. The application of the forceps demands

[1] Fisher, Senile Cataract, Chicago Eye, Ear, Nose and Throat College, 1923.
[2] Arch. Ophth., vol. 1, May, 1929.

spoon is introduced behind the lens and the lens extracted thereby. The fourth is the method of Barraquer and later of Fisher and of Dimitry, using a suction cup erisophake. Electrocoagulation and extraction of the lens through its adherence to the electrode also belong in this group; though this last procedure is not recommended.

The Smith-Indian method depends upon the application of pressure on the outside of the eyeball to rupture the zonula and to extract the lens by the continuation of the pressure, though its position and direction must be changed as the lens adjusts itself into various positions. As said before, the hydrostatic principles behind this technique depend upon the equaliza-

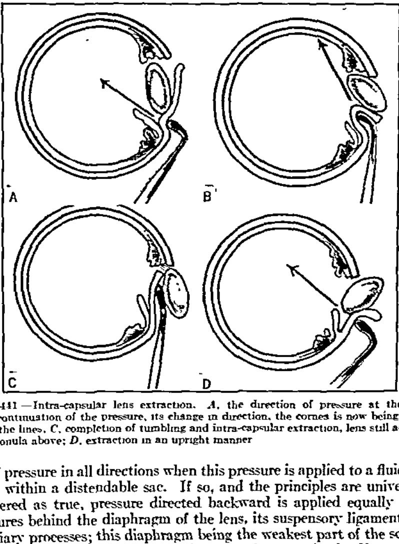

FIG. 441 —Intra-capsular lens extraction. *A*, the direction of pressure at the start; *B*, the continuation of the pressure, its change in direction, the cornea is now being tucked behind the lines, *C*, completion of tumbling and intra-capsular extraction, lens still adherent to the zonula above; *D*, extraction in an upright manner

tion of pressure in all directions when this pressure is applied to a fluid contained within a distendable sac. If so, and the principles are universally considered as true, pressure directed backward is applied equally to all structures behind the diaphragm of the lens, its suspensory ligament, and the ciliary processes; this diaphragm being the weakest part of the scleral-diaphragm shell, it must break, and the break occurs in the fibers of the zonula. The massage to the eyeball with the pressure hook, the thumb, or the spoon, controls to a great extent the site of the break, the ideal being below with the superior portion remaining hinged. Because of this, the continuation of the pressure tilts out the freed lower pole of the lens, compelling it to go upward and anteriorly through a rotation which approaches 180

degrees. This tumbling, therefore, results in the presentation of the lower pole of the lens first in the corneo-scleral incision. At the same time the lens acts as an effective cork against prolapse of the vitreous. This effect will be lost, however, unless the pressure which is being applied is continued without intermittent relaxation and application. Figure 441[1] illustrates this: *A*, the direction of the pressure at the start; this is then changed by continued tilting so that the hook is directed down toward the ciliary ridge; *B*, the continuation of the pressure, its change in direction, and the cornea is now being tucked, as it were, behind the lens; *C* shows the completion of the tumbling and the intra-capsular extraction.

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In right handed individuals, the forceps should be applied with the right hand, and the hook with the left. The application of the forceps demands

[1] Fisher, Senile Cataract, Chicago Eye, Ear, Nose and Throat College, 1923.
[2] Arch. Ophth., vol. 1, May, 1929.

finer manual dexterity than that necessary for using the hook. Hence, the right hand is the proper one to use for manipulating the capsule forceps.

The forceps delivery is essentially that of Stanculeanu[1] and of Kalt.[2] This consists in grasping the capsule firmly with cup-tipped forceps and by the application of pressure outside of the eye, and by a rocking, to-and-fro movement of the lens inside of the eye with the forceps, the zonula fibers are ruptured, and the lens is dislocated. The grasp from these forceps should be applied universally as far down toward the inferior equator as it is possible.

The forceps is introduced into the eye from above, and closed, preferably with the right hand (except in left-handed individuals). It is passed across the anterior chamber to the edge of the iris, the blades permitted to separate about 2 mm., and then gently but firmly applied to the capsule. The blades are then closed, picking up a bit of the anterior capsule as a fold or a dart (a dressmaking term). There is a danger of opening the blades of the forceps too widely so that when they are closed the amount included within their grasp is greater than the elasticity of the capsule will stand. As a result, this piece of capsule will be torn out making intra-capsular extraction impossible. The Verhoeff forceps[3] is constructed with a "stop" so that the blades cannot spread unduly. (Fig. 11.) Insufficient pressure in the application of a pair of forceps will not give an adequate grasp of the capsule or the blades will simply slide over the capsule fruitlessly. This frequently occurs in mature and hypermature lenses, for in these the capsule is taut and with smooth surface so that all types of forceps tried will be unsuccessful. If too much pressure is applied, the lens may be dislocated posteriorly with the immediate herniation of vitreous into the anterior chamber. Even with this, slight pressure below with a hook will support the lens sufficiently long so that an adept operator can still grasp the capsule in the forceps and proceed with the extraction. The statement illustrates the ease and the lightness with which the forceps can and must be applied in many instances.

The lens when it dislocates tilts upward and forward, to appear in the anterior chamber with its lower pole first. The assistant is frequently the first to know that the lens has been dislocated. His direction of gaze and his position at the operating table makes possible an early observation of the dislocation. Many times it rises rather abruptly from the vitreous and through the pupillary aperture, anticipating further traction by the capsule forceps. At times the lens, even though satisfactorily dislocated, has a disinclination to leave the eye. One can see lines of tension in the capsule where it is grasped by the forceps. The size of the lens and the size of the corneo-scleral aperture are both important factors at the time. In such instances, the oncoming hook as it follows the inferior pole of the lens upward along the cornea must be used, though judiciously and expertly, to relieve this pull upon the capsule. Repeatedly the capsule will tear, somewhere on its circumference and be extracted in its entirety, but the nucleus of the lens slips back into the anterior chamber through the rent in the capsule. When this occurs, a broad spatula or a spoon must be used to depress the posterior lip of the corneo-scleral incision, and with the hook upon the cornea, necessary pressure is supplied for delivering the retained nucleus.

[1] Klin. Monatsbl. f. Augenh., 1, 527, 1912.
[2] Ann. d'ocul., 143, 436, 1910.
[3] Verhoeff, Trans. Am. Ophth. Soc., 25, 54, 1927.

The procedure is exactly that which one would carry out in completing a capsulotomy extraction.

One cannot be sure which is the greater factor in achieving the dislocation, the pressure backwards with the hook and its resultant of forces against the posterior surface of the lens and the suspensory ligament diaphragm, or the side-to-side shaking of the lens within its suspensory ligament. It seems, at times, as if the posterior pressure of the hook furnishes nothing except adequate support for the application of the forceps to the capsule. If so, the lens is probably dislocated almost wholly by the forceps itself, though the continuous outside pressure is perhaps responsible for tipping the lower pole of the lens out and up. If the forceps is the more important of the two in achieving dislocation, the outside pressure must be so delicately controlled that the oncoming lower pole of the lens is well in contact with the posterior surface of the cornea all the time, even with the reapplication of posteriorly directed pressure. Otherwise a brief interval of time is present during which vitreous may be herniated and driven out in front of the lens.

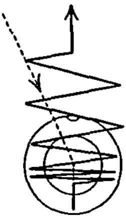


FIG 442

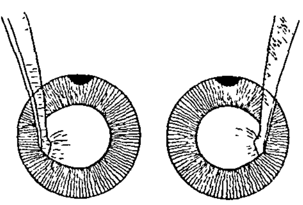


FIG 443

FIG. 442 —Technique for intra-capsular extraction Schematic drawing of movements or course made by the ends of the forceps[2] (Arruga.)

FIG. 443.—Technique for intracapsular extraction. Lateral zigzag movements. The *peripheral iridotomy shown indicates the upper limbus of the eye*

Figures 442 and 443[1] are sketches of Arruga's, the first view (Fig. 442) shows with a dotted line the initial movement, the position for grasping the capsule with the forceps, and the solid zigzag line illustrates the motion necessary to dislocate the lens from its suspensory ligament and to extract it. Arruga uses a hook, quite different in shape from the usual cataract hook; it is almost a shepherd's crook curve fitting over the cornea in its entirety as in the figures following. Figures 444 through 447 show its action and effect, which is not so much of the hydrostatic transmission of the force applied by the hook through the vitreous as it is the enclosure within its curve of the lens itself during the extraction. The illustrations not only depict the method in which Arruga uses the hook, the position for

[1] Arruga, Conferences Ophthalmologiques, Lausanne Imprimeries Reunies S. A., 1937.
[2] Figures 442–447. Arruga, Conferences Ophthalmologiques, Lausanne Imprimeries Reunies, S A , 1937.

rasping the capsule, and the fact that the lens as it is being extracted is moved not only by upward traction but also by an outward pull.

From this point, the completion of the extraction is essentially that of the tumbling maneuver of the Smith-Indian method. The two methods of completing it are: *first, that of Elschnig*[1] *and many others, wherein the grasp* is maintained on the capsule and the lens is expressed in this way, its inferior pole presenting, if not first, at least in its major portion, the superior edge remaining hinged to its zonula fibers until the very end of the extraction. If tumbling does not occur, the operator may discover that he is extracting the lens by a maneuver quite similar to that of lifting a stove

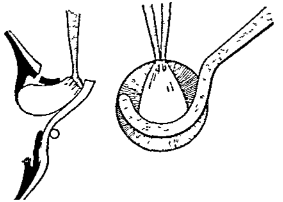
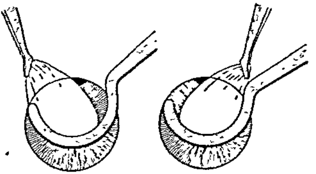


FIG. 444 —Technique for intra-capsular extraction. The hook approaches the operative wound in order to help overcome the resistance of passage across the pupil and the wound. (Arruga.)



445.—Technique for intra-capsular extraction. Zigzag movements that ought not to be stopped until the complete issuance of the crystalline lens. (Arruga.)

from the stove with an iron handle. In such instances, the plane of the greatest diameter of the lens remains roughly parallel, throughout its extraction, to the plane of the iris. The other of the two maneuvers is that instituted by Knapp. He releases his hold upon the capsule as soon as the lower pole has been dislocated and expresses with a hook the same as that outlined in Figure 441. Figure 443 illustrates the application of the Arruga forceps, their inferiorly placed grasp and the inferior pole dislocation, with the support of and the backward pressure being applied through the hook, and the front view of the same.

After the dislocation has occurred, the subsequent extraction depends

[1] Arch. f. Augenh., 98, 300, 1927.

wholly upon the individuality of the operator and upon his training. In properly selected cases, the incidence of vitreous prolapse, or of any other complication, is probably no greater with the one than with the other. The excellent results of both methods and the eminence of the men practicing them are adequate evidence perhaps of their equal value.

Practically, the application of Knapp's and Elschnig's extraction technique is not wholly a matter of personal "likes and dislikes" for each has optimum indications. In all cases with contracted and calcareous lenses, and in eyes wherein it is logical to expect a fluid vitreous, the extraction should be completed without releasing the hold of the capsule forceps, *i. e.*, Elschnig's method. Other cases with large swollen lenses, and cases with apparently normal and healthy vitreous may be completed by Knapp's technique, *i. e.*, releasing the hold of the capsule forceps after dislocation of the lens (from a satisfactorily ruptured zonule) and utilizing the hydrostatic possibilities of the healthy vitreous by posteriorly directed pressure.

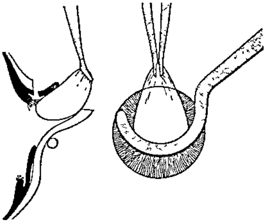


FIG. 446 —Technique for intra-capsular extraction Continuing the pressure of the key and the zigzag movements, the zonule of the superior part is torn in turn (Arruga)

To recapitulate Knapp's technique[1] briefly:

A broad limbal incision is made with a conjunctival flap. An iridectomy is then performed because of the greater ease of delivery of the lens and less frequency of prolapse. Careful reposition of the pillars follows iridectomy The lower third of the anterior capsule is grasped with the blunt Kalt forceps, and the lens manipulated from side to side, with firm pressure straight back at the limbus with the blunt hook. If the capsule eludes the grasp of the forceps, a broader bite is taken without pressing the forceps together too hard If the capsule still eludes or if it does not subluxate after an amount of manipulation that is considered safe, the toothed forceps are used.

(Knapp has found no reason to modify the original Kalt model of capsule forceps.)

As soon as the separation of the suspensory ligament below has taken place, traction is arrested and the forceps are disengaged. The section is then enlarged with the scissors if necessary. Pressure is exerted externally straight back at the lower limbus, with counterpressure above over the scleral lip of the incision, and the cataract should present by tumbling. As soon as the rotated lens comes to be placed horizontally, pressure backward is relaxed and the direction is changed to upward,

[1] Arch. Ophth., vol 10, July, 1933.

i. e., away from the vitreous. After the emerging lens has passed the equator of the incision, its final adhesion above is swept free with the curved part of the hook working upward. After extraction the lids are closed for a few seconds to allow the incision lips to adjust themselves, and any presenting vitreous to retract. The iris pillars are again replaced, and a bandage applied without the use of any sutures.

For intra-capsular extraction either of the three forms is excellent for hypermature cataracts, except Morgagnian; for these it is unsuited. It is also unsuited to friable capsules, which give way more rapidly than the zonule. Although it is said that in such cases one has a perfectly good capsulotomy and can proceed to evacuate the nucleus and cortex, in practice such a smooth forceps capsulotomy may result in an irregular tear running into the equatorial region, and an accidental zonule tear as well, but with the pupillary area of the capsule still intact. If a capsulotomy is

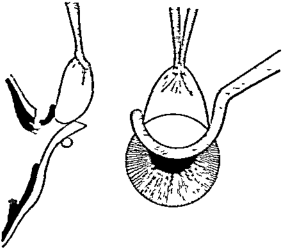


FIG. 447.—Technique for intra-capsular extraction. Final extraction of crystalline lens (Arruga.)

performed with forceps, it must be deliberate, not an accident, and made with a suitable instrument. Old arguments for and against extraction in the capsule are still produced, but Pagenstecher's chief criterion is still best. Each case is determined on its own merits, but it is largely the condition of the zonule which decides. When one finds distorted pupils, boat-shaped pupils, vitreous threads adherent to the angles of the wound throughout the section, or invading the angle, it is well if the vision is good, for the operator has done a very poor job from a mechanical point of view.

Irrigation of the anterior chamber is unnecessary and may be dangerous following an intra-capsular extraction. If hæmorrhage is extensive into the anterior chamber it probably should be irrigated therefrom, but hæmorrhage should have been controlled before the extraction. Seepage into the anterior chamber from the lips of the wound is probably the source of the hæmorrhage, and the operator ought not proceed with the extraction until this has stopped.

LOOP EXTRACTIONS

The loop extraction is usually a procedure which must be done in and as an emergency. Because of this, a lens loop belongs on the instrument table

for every cataract extraction, even though the necessity for its use is, fortunately, limited to but few instances.

Under some circumstances, an extraction is definitely planned as a loop extraction, however, and it is remarkable how satisfactory some of these cases are. Considering these first, they will include those cases with a frank dislocation of the lens, present even before the eyeball has been opened. It is barely possible that cases of ectopia lentis may be included herein. If occasion should arise wherein an intra-capsular lens extraction would be indicated in one of these, one need not hesitate to use this maneuver. Dislocation into the anterior chamber, recent dislocations into the vitreous, and recent partial dislocations, all three types traumatic, are the probable conditions. In those cases with anterior chamber dislocation, a keratome incision would be necessary for the extraction. In others, a keratome incision can be used, but regardless of whether a keratome or a von Graefe knife is used, the surgeon must be certain that a conjunctival flap will be available for subsequent closure of the corneo-scleral incision. It makes little difference whether this is a corneo-conjunctival flap or a sliding conjunctival flap, but one is necessary because a certain amount of vitreous may be lost, even under the best of circumstances.

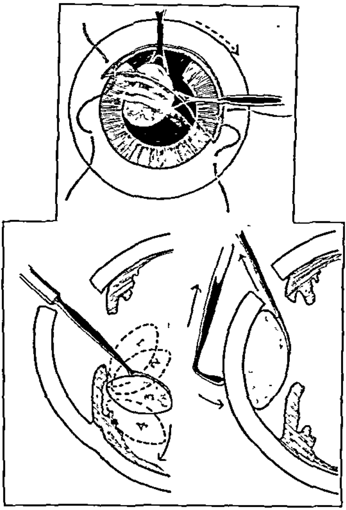
Posterior dislocations, if still hinged at some place on the zonula, can occasionally be floated into the anterior chamber through a dilated pupil before a section is made, by changing the position of the patient, augmented by digital pressure upon the eyeball posteriorly. The author has achieved this in several instances wherein a patient was placed upon his face, the lens coaxed through the dilated pupil into the anterior chamber a sufficient amount so that subsequent and immediate myosis with amino-glaucosan held the contracted iris and the lens firmly for subsequent intra-capsular lens extraction with the capsule forceps. Attention has already been called to Knapp's recommendation for elevating a posteriorly dislocated lens after the corneal section by similar digital pressure applied as far posterior as is possible. Both of these should be tried before "fishing" for a dislocated lens. The position of the lens must be carefully noted before the patient reaches the table, so there is no unnecessary stirring up of the vitreous by the loop.

The ideal procedure is to make a large corneo-scleral incision; follow this with a complete iridectomy; pass the lens loop, smooth or serrated, down into the vitreous with the concavity of the loop behind the lens; lift the lens forward against the ora serrata of the retina and later the cornea, and withdraw it in this manner through the section. As soon as the lens is engaged the extraction should be completed without hesitancy and without rough or jerky movements. If the lens is still hinged near 12 o'clock, the corneal section should be made with its greatest circumference lateral to the 12 o'clock meridian, that is, puncture at 4 to 5 o'clock and counterpuncture at 1 to 2 o'clock. The iridectomy can still be made at 12 o'clock without any difficulty. If the dislocation is complete except for a 6 o'clock hinge, and preoperative digital manipulations are also unsuccessful, then it will be necessary to pass the loop quite deep into the vitreous to engage the dislocated lens.

Figure 448, *A*, shows the relatively simple maneuver for extracting a dislocated lens with the loop when the zonula is still intact above as a hinge. This maneuver is successful in all instances where the lens does not fall

away from the corneo-scleral incision, as in *B* with the three positions, though one always has the alternative of changing the position of the corneo-scleral incision line so that the more satisfactory circumstances of *A* can be met. In the case of 3 of *B*, the extraction would be achieved by the loop being passed down parallel to the plane of the iris, the handle tilted away from the forehead, the lens engaged as low as possible upon its anterior surface now directed posteriorly, the handle then moved toward the

A



B C

FIG. 448 —Loop extraction.

forehead, dislocating the lens even more until it is now resting in position 4 of *B*. With the incision as the fulcrum and with the lens nested securely in the ring of the loop, it is extracted from the eye by a smooth upward removal of the entire instrument, as in *C*, the handle, however, being tilted more and more toward the forehead as the lens is brought out of the eye. In this way, one follows the normal configuration of the sclera and the cornea, and at the same time corks the aperture of the chamber to restrain the vitreous as much as is possible. If the dislocated lens lies in the position

of 1 or even 2, it may be possible to apply pressure with the hook against the sclera, where the arrow points in *C*, and to elevate the lens sufficiently so that it can be grasped with a capsule forceps. Too often, however, it will bounce away from the capsule forceps. Fisher recommends the use of his needles for raising the lens under such circumstances. The needle is stuck into the lens and the continuation of the pressure below the lens passes the equator into the anterior chamber and it can then be extracted with the hook as is usual. Fisher[1] says, relative to the use of this needle, that it is quite reasonable to infer that the more often the needle is used, the more capsules will be ruptured, but also many hard lenses may be removed in their capsules by the use of the needle. To offset the complication of burst capsules, Fisher claims less vitreous loss. The needle should be stuck well into the lens so that it is firmly impaled upon the needle. In so far as the loop is concerned, Fisher prefers the broad spatula or spoon of Smith rather than the loops. He feels that the spoon is the less dangerous of the two instruments. (The writer cannot agree with him relative to this statement, but in the final analysis, these opinions are purely personal and need not necessarily be general; the difference of opinion indicates the value of each.) If positions 1 and 2 cannot be extracted by pressure or by pressure augmented with a capsule forceps, or a needle, then one must force the lens down with the loop or the spoon to position 3 and proceed with the extraction as if the dislocation originated from position 4.

The second instance wherein the loop or the spoon must be used is that unfortunate circumstance or condition wherein vitreous presents prior to the lens extraction. In these instances, the lens is dislocated most frequently above, while the corneo-scleral incision is being made. The operator may be aware of this dislocation immediately, but it is more common to find vitreous presenting the moment pressure is applied for the extraction. Here also Fisher and some other operators use the needle, sticking it into the lens immediately and extracting with this assistance. For these cases, however, and with this degree and type of dislocation, the loop is the more logical of the two instruments. The eye is steadied by the assistant with the bridle suture, the hook applied to the limbus below, but without pressure, and the lens loop passed directly into the corneo-scleral incision almost perpendicular to the plane of the cornea. The curve of the loop is applied to the posterior convexity of the lens, so that, promptly after the introduction of the loop, one must swing the handle toward the forehead to engage it properly against the posterior surface of the lens. As soon as the engagement has occurred, the lens is lifted up slightly and then expressed with its long axis parallel to the plane of the iris, the point of counterpressure being the posterior surface of the cornea, but this is restrained by the hook on its anterior surface so that there is no undue gaping of the aperture in the anterior chamber. This restraint, by the hook, is actually the point of counterpressure. The hook, thus applied, furnishes firm support so the lens slides up and out on an inclined plane. The introduction of the loop should not result in further vitreous loss itself, and if the hook is properly and expertly applied externally, the lens can be slid out between hook and the spoon in such a manner that no further vitreous loss is necessary. The procedure is so satisfactory that it is to be recommended in every instance wherein the section, or the subsequent iridectomy

[1] Senile Cataract, Methods of Operating, Chicago Eye, Ear, Nose and Throat College, 1923.

(if this is done), has resulted in a dislocation. The dislocation may have occurred, not because of clumsy or heavy handed manipulations, but simply because the patient has squeezed, at some time during these manipulations, sufficiently to rupture the zonula at some place. It is not a common complication. It can also occur during the preëxtraction irrigation of blood from the anterior chamber. The operator or his assistant may see the lens moving within the eye during this irrigation. (This subject will be referred to again in the consideration of the complications connected with lens extractions.)

SUCTION EXTRACTION

The extraction of a lens within its capsule, by suction, was recommended as early as 1910 by Hulen.[1] Clapp[2] abstracted Hulen's technique and presented it as a preliminary to his discussion of the intra-capsular lens extraction by suction. Two paragraphs from this technique are as follows:

> The cup of the vacuum extractor is introduced from the side of the section and gently placed on the anterior capsule of the lens. . . . . the patient at the same time should look straight ahead, never down. If the pupillary margin is everywhere free, the nurse is directed to turn the cock at the gauge. The vacuum cup will then grasp the cataract most rigidly. The lens should be slightly lifted and rotated on its anterior posterior axis to sever the suspensory ligament; then with the upper edge slightly advanced, the cataract in its cup is slowly and gently lifted out through the section. The suture is immediately tied safe from the loss of vitreous, we now replace the edges of the coloboma with the iris repositor (introducing it to each side of the knot) and perform the usual toilet of the eye without apprehension. A negative pressure of from 20 to 25 is used.

This suction principle is the basis upon which Barraquer[3] first presented his technique which he spoke of as phacoerisis, also known as phakoerisis, "Un procédé d'extreme condeur pour l'extraction *'in toto'* de la cataracte." Phakoerisis as Barraquer describes it[4] is as follows:

> Phakoerisis consists in drawing the crystalline lens by its anterior surface, separating it mechanically without either traction or violence of the zonula, and extracting it completely, out of the eyeball, without having produced ectopias or traumatisms to the intra-ocular structures The instrument employed, called the erisifaco, is nothing more than a pneumatic forceps and a zonulatome.

Barraquer continues in his essay with a detailed description of the *machine and principles underlying it. The pump to the machine* which is operated by a motor, produces repeated periods of vacuum in the tube and in the suction cup, the frequency of them depending upon the rate of revolutions of the motor. In this way, a vibratory action is given to the suction cup as it rests against the anterior capsule of the lens. It is because of this vibration and the rupture which results from it that Barraquer feels justified in speaking of his machine as pneumatic forceps and a zonulatome. The rarefaction of the air in the tiny suction cup as it adheres to the lens deforms the lens, shortening its greatest diameter and displacing the nucleus toward the suction cup itself. The vacuum which he uses varies between 50 and 70 cm. of mercury, according to the elasticity of the lens or the state of the

1 Trans. Sec. Ophth , Am. Med. Assn , p. 73, 1911.
2 Cataract, Etiology and Treatment, Philadelphia, Lea & Febiger, 1934.
3 Clin. Ophth , 22, 328, 1917.
4 Fisher, Senile Cataract, Chicago Eye, Ear, Nose and Throat College, 1923, Chap. 2, Intra-capsular Method by Ignacio Barraquer, transl by A. G. Wipern.

maturity of the cataract. Figure 449, A, shows the erisophake as it is being applied to the anterior capsule of the lens, and B, the erisophake in its diagrammatic cross-section with the deformity which results in the lens, the displacement of the nucleus and the rupture of the zonula which occurs by reason of this displacement. The two forms of extraction which Barraquer recommended, both start from this position. Too great an intensity within the erisophake may result in rupturing the lens capsule, and too little will prevent rupture of the zonula, and the lens will not adhere firmly to the erisophake. In the case of the first the operation must be completed by the routine capsulotomy procedure; in the case of the second, if reapplication of the suction is unsuccessful, some other procedure must be instituted and the machine repaired after the operation. Barraquer's description for the simple extraction as well as for the tumbling extraction follows herewith. The latter of the two is his usual method, though the former of the two is utilized usually in Morgagnian cataracts and in the hard and contracted cataracts.

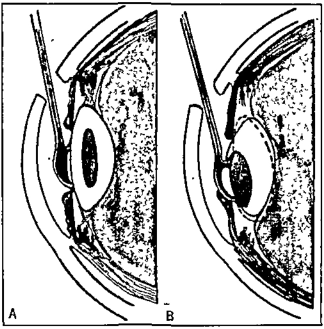


FIG 449.—Barraquer's erisophake and extraction

Once having caught hold of the crystalline lens by the force of the vacuum, and torn the fibers of the zonula, in order to withdraw the cataract from its position, if an iridectomy has been made, it is sufficient to raise its superior border while it works upward, in such a way that the inferior border of the lens follows the curve of the patellar fossa, in contact with it, without exerting the least pressure or producing friction on its posterior surface. To finish this operation, we direct the cataract at this time toward the scleral lip of the wound, raising the flap by the suction cup which is introduced into the anterior chamber.

His tumbling or usual procedure follows herewith as to technique.

Simple extraction with the peripheral iris buttonhole is made, and the lens is removed by its inferior border, or upside down, which is obtained by making it rise at first directly from above, less than 1 mm. toward the corneal incision and

making its inferior border rub on the posterior surface of the iris, in which movement all the posterior surface of the iris, remains in contact with the posterior part of the cornea.

This procedure is achieved by a slow rotation of the erisophake so that the lens is turned out of the patellar fossa and extracted with its posterior surface facing outward and the curve of the erisophake now directed posteriorly. This rotation of the erisophake should not be started until the lens has been lifted very slightly out of its patellar fossa. At the same time it is done, the handle of the erisophake should be inclined toward one side or the other, depending upon which eye is being operated upon, so that the maneuver is completed with the handle of the erisophake lying at a 45 degree angle between the vertical and the horizontal meridians of the cornea directed outwardly toward the temple. In using the erisophake the corneal section must be as large as is possible. If a complete iridectomy is not done, then it is most important that the pupil be widely dilated as well. Barraquer ordinarily did his peripheral iridectomy after the lens extraction. The remaining steps of the operation are in no way unlike those of any classical lens extraction.

There is no doubt that the erisophake does permit the intra-capsular extraction of many lenses which could not be extracted otherwise in the capsule, or at least there would be difficulties with the extraction within the capsule. This includes immature lenses in the late adult and presenile years, hard and contracted lenses, and Morgagnian and hypermature lenses. On the other hand, regardless of the operator who is using the erisophake, there is a greater incidence of vitreous loss with the procedure. If the operator is satisfied that the advantage offsets this disadvantage, well and good. Circumstances do appear and cases do present themselves wherein this controversy will appear and must be considered. Many men use the technique and have used it in indicated cases with great satisfaction.

The vitreous prolapse which occurs following an erisophake lens extraction is, however, not the greatest single defect. It is that ever-possible possibility of complete evacuation of the vitreous body through the suction cup of the erisophake. It may occur because of dislocation of the lens at the time of applying the cup, or because of a release of the lens from the vacuum cup after the lens has been dislocated, usually because of a capsulotomy which the erisophake occasionally causes. In both of these instances the only positive warning which the operator has is the abrupt drop in suction pressure on the gauge and the sudden faint sucking or swishing noise. The catastrophe is a grave one and means, naturally, the loss of the eyeball.

Green, of San Francisco, a strong advocate of intra-capsular extraction, has devised his own erisophake, and it is apparently satisfactory not only in his own hands but also in those of others. Wright[1] reviewed a series of 50 cataract extractions which he did with Green's apparatus, and he feels that phacoerisis should have a much more extended trial, adopting any minor deviations suggested by those with a considerable experience in its use and who have an almost daily familiarity with the difficulties of cataract extraction. Nugent[2] has also devised his own erisophake, with a

[1] Trans Ophth Soc. United Kingdom, vol. 47, 1927.
[2] Nugent and Fisher, Illinois Med Jour., 64, 320, October, 1933, and Nugent, Texas State Jour. Med., 32, 664, February, 1937.

modified suction cup and an oral vacuum valve, the suction pressure being obtained from an electric motor coupled with a rotary vacuum pump. There is no doubt that with a trained force, very satisfactory results should be obtained through this technique.

Dimitry[1] presented an instrument for vacuum extraction as illustrated in Figure 450.

The instrument embodies a cylinder in which a plunger operates to produce a vacuum and to which a hollow grasping stem is connected. Between the cylinder and the stem is a valve by means of which communication between the cylinder and the grasping stem may be established or cut off; this valve may be used to release the vacuum from the stem, and yet permits a vacuum to remain in the cylinder. *D* in the accompanying figure is a perspective view of the instrument, showing the

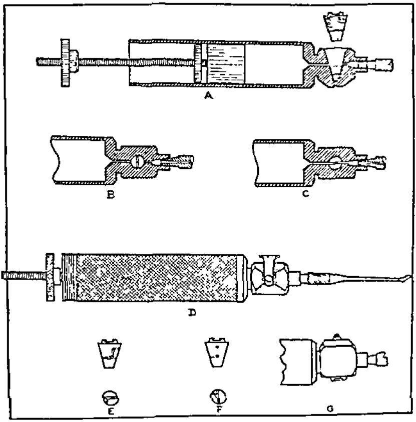


Fig 450 —Erisophake (Dimitry)

cylinder, the valve and the stem. *A* is a section taken centrally and longitudinally through *D*. *B* and *C* show how the communication between the cylinder and the stem is made by the action of the valve, *E*, *F*, and *G*. In *A* the space between the larger and smaller plunger is filled with an extra heavy cup grease. The instrument is comparatively small and consequently has a limited vacuum chamber, yet it has been made to perform successfully. It can be reduced still further, and in my (Dimitry) opinion will perform equally as well, for a large volume vacuum space is not necessary to obtain a most satisfactory vacuum grasp, and if it is machined to perfection, its simplicity and ease of manipulation are calculated to give it recognition and trial. The method of use is first to make certain that the valve is closed, which is the case when the valve is half way between its forward and backward extent of movement. To produce the vacuum the plunger is then pulled out, and

[1] Arch. Ophth., vol. 9, February, 1933.

in the extended position is ready for use. With the stem well attached, it is inserted through the incision into the eye, and the operator decides on the area of the lens with which he intends to make contact, and after this is accomplished the valve is opened by pushing the valve handle forward, which thereby permits communication between the valve, stem and cylinder chamber. The vacuum grasp may be released by pushing the handle backward and in so doing the vacuum in the cylinder is not lost, because the movement of the valve opens a small hole in the valve which communicates with the stem but not with the cylinder.

Lacarrère[1] made use of a high frequency current by means of a needle machine which he calls the electro-diaphaque. After his corneal section in the usual manner, and an iridectomy, the needle of the electro-diaphaque is pushed into the anterior capsule of the lens, slightly below its center, and the current turned on. A certain amount of coagulation occurs, resulting in adherence of the lens to the needle. The lens is then dislocated by means of the needle, and removed through one of the two manipulations which Barraquer has recommended, that is, either directly or by tumbling. Lacarrère himself reported excellent results by this method.

CATARACT EXTRACTION FOLLOWING GLAUCOMA

The extraction of a cataracterous lens following a fistulizing operation for a preëxisting glaucoma is in general not too well handled. In many instances, following recovery from the cataract operation, the filtering cicatrix is lost due to the scarring of the ordinary cataract corneal section. Several means of preventing this complication are available. Perhaps the simplest and that used by the author is to make a corneal section below, if the cicatrix is above, expressing the lens through this. Usually an additional iridectomy is not necessary and certainly it should not be necessary if the filtering operation has been combined with a complete iridectomy as in an iris inclusion operation, or as is done in many trephining operations. If an iridectomy must be done it should be made as small as possible, below, enough to simply break the sphincter. Conjunctival and corneal-scleral sutures may be used here as readily as with the superior incision.

McLean[2] uses a technique which is well worth considering. Two small perpendicular incisions are made at the upper part of the limbus in the clear cornea to about 0.5 mm. thickness. These incisions are placed to either side of the site of the glaucoma operation and just far enough forward so the cataract section on emerging through the incisions will conveniently clear the filtering area. A silk suture on a corneal needle is placed through the lips of each pair of slots, and the central portion of the suture as loops are withdrawn and laid aside to make room for the cataract knife. An ordinary cataract knife is used to make the section starting in the classical fashion and emerging through these prepared slots and sutures. After the cataract is removed the wound may be immediately and firmly closed by the two sutures. In this way the fistualizing cicatrix of the former glaucoma surgery will be spared.

Gifford[3] does his extraction somewhat differently. He uses an inferior lateral incision on the right eye from 1 to 5 o'clock position and on the left eye from 1 to 7 o'clock position. Corneal-scleral sutures are utilized as is

[1] Klin. Monatsbl. f. Augenh., 88, 778, 1932.
[2] Am. Jour. Ophth., Ser. 3, vol. 25, No. 2, February, 1942.
[3] Am. Jour. Ophth., Lancaster Testimonial Issue, Ser. 3, vol. 26, No. 5, May, 1943.

customary. Fixation is on the superior and external recti muscles. The former is held by a fixation forceps and the latter by a suture. The section is made with the usual cataract knife, but because of the unusual location a smaller section is made with the cataract knife and this is completed with humming-bird bill scissors. An iridectomy is performed in a horizontal line upon the side of the eye as and when necessary.

RECAPITULATION OF MAJOR CATARACT PROCEDURES BY THE INTRA-CAPSULAR METHOD WITH OR WITHOUT A COMPLETE IRIDECTOMY

The comparison of the visual results following combined extraction, simple and intra-capsular extraction is rather well illustrated by Parker's report of 450 cases[1] wherein 150 operations of each type were done and reviewed. The tables below give a comparison of the visual results, and a comparison of the complications.

NUMBER OF CASES

	Loss of vitreous	Prolapse of iris	Infections
Combined	3 (2%)	2 (1 3%)	1
Simple	5 (3 3%)	6 (4%)	1
Intra-capsular	9 (6%)	3 (2%)	1

COMPARISON OF VISUAL RESULTS

	Per cent of total No of cases		Per cent of cases after all pathological conditions were eliminated	
Type of operation	Vision of 6/12	Vision of 6/15	Vision of 6/12	Vision of 6/15
Combined	83 3	91 3	87 4	95 8
Simple	77 3	82 6	87 2	93 2
Intra-capsular	75 3	84 0	84 3	94 0

It is remarkable to see that the usual results from the combined extractions are perhaps slightly better than those seen in the intra-capsular extractions, and after all pathological conditions were eliminated, there is no choice whatsoever in the visual results between the various operations. Wright[2] felt that:

> The immediate postoperative results by the intra-capsular method were better than those attained by capsulotomy, provided it was carried out without undue displacement of vitreous or involvement of the iris in the section, the general question arises as to the best and safest method of removing the lens in its capsule and the type of cases to which this method should be applied. There was choice between expression (Smith) and phacoerisis (Barraquer) and removal with force, after the so-called Stanculeanu or Knapp method. We consider that the latter ought to be referred to as Terson's method (1871) although we often refer to it as Knapp's method, since he rejuvenated it in India. The Smith technique is excellent in some cases in experienced hands, but when adopted by the average operator, it is liable to give rise to undue trauma. In the hands of the inexpert, it is quite likely to give a very high percentage of poor results, such as drawn up pupils, vitreous escapes, vitreous adhesions to the flap, and so on. In the hands of an expert, we consider it is eminently suitable for Morgagnian cataracts and types of cataract with very weak zonules, in eyes of the non-bulging, low tension type. It has its place in any big clinic. The resistance of the zonulæ, the condition of the vitreous, the intraocular tension (actual or potential) are the key points in all three procedures. It is most disappointing that the very condition for which we most required the Barraquer procedure, namely the immature cataract, is that in which it cannot be recommended to any but the most expert, and even than a grave risk to the patient is involved.

[1] Arch. Ophth., vol. 11, January, 1934, Wilmer Number.
[2] Am. Jour. Ophth., Ser. 3, vol. 16, March, 1933.

Cruikshank[1] discussed 1322 cases done by Holland. Of these, 1241 were extracted in the capsule. Holland is convinced that the intra-capsular method is not the operation of choice in many cases.

Of the three classes, juvenile, congenital, and secondary, universally considered as not acceptable, he adds, (1) the ox-eyed type of patient with prominent eye, (2) double cataract in healthy men from thirty-five to fifty years of age in whom the zonula fibers are very resistant and require pressure for their rupture, (3) cases of glaucomatous cataracts in which preliminary iridectomy is advised (in these the incision must be made slowly the aqueous being allowed to escape slowly and to balloon out the conjunctiva), (4) traumatic cataracts in which prolapse of the vitreous is likely to occur, (5) cataracts in which ordinary legitimate pressure fails to rupture the lens Only moldable cataracts, *i. e.*, the intumescent and mature varieties are suitable for tumbling and certainly no attempt should ever be made to tumble these cataracts which fall in group 5 above.

If a conjunctival flap is not obtained, the operator must immediately decide on the advisability of introducing corneo-scleral sutures, of forming a sliding flap or permitting the postoperative recovery to proceed without any sutures at all. This opinion can be arrived at only by knowing the patient, his preoperative medical condition, his disposition and temperament and, from these, drawing as accurate a conclusion as is possible. Hæmorrhage from the section is staunched with adrenalin-moistened sponges to prevent its seepage into the anterior chamber. In placing the sutures, the operator should use a very fine straight conjunctival forceps and a needle holder which does not lock. The author's model naturally gives him satisfaction. Equally good work can be done with an ordinary mosquito type needle holder, though this should not be locked, simply used as a springless needle holder. The operator must decide whether to continue the operation after the section without an iridectomy, with a complete iridectomy, or with a peripheral iridectomy. He should have formed in part an opinion relative to this before the operation, and in many instances can continue with this prearranged plan. Circumstances, however, modify it wholly. There is no doubt that many of the iridectomies which are done with a cataract knife by the iris falling in front of the knife are beyond the control of the operator. Other factors, however, are also connected with this. The loss of the anterior chamber occurs most commonly not at the time of the puncture, but at the time of the counterpuncture, in that when this is made, the knife point perforates and cuts at the same time. The perforation is proper, but the cutting should be delayed for a brief moment. Knapp's plan of depressing the diaphragm of the iris and the lens by the pressure of a moistened sponge to the cornea behind the back of the knife may be attempted. If this is unsuccessful, the incision must be completed and the iridectomy done in as workmanlike a manner as is possible.

It the iris continues to prolapse and will not be replaced, a peripheral iridectomy may be tried. If this permits the replacement of the iris, everything is satisfactory; if not, a complete iridectomy is necessary. Other factors which further modify the advisability of the iridectomy are: the size of the pupil, the degree of maturity of the lens, the age of the patient, the presence of preëxisting hypertension, the presence of synechiæ, the blood-pressure of the patient, his general condition—even the state of his other eye is one of the factors utilized in deciding this point.

[1] Indian Med. Gaz Calcutta, 58, 461, October, 1923.

If a peripheral iridotomy is deemed proper, the flap is reflected over the cornea to expose the root of the iris, this sponged free of blood, and a linear iridotomy made with the knife needle crossing the course of the fibers of the iris. Wheeler[1] also feels that a simple straight incision across the iris muscle fibers, as done with his straight knife needle, is quite satisfactory. The other alternatives are to pick up the iris at its root with Hess or Fuchs iris forceps, and without withdrawing the iris to any appreciable extent, the iridotomy is completed by cutting the iris tissue within the blades of the forceps as close to them as possible. If de Wecker type scissors are used, the plane of the blades should lie tangentially to the cornea and the lower of the two blades to be actually within the anterior chamber.

If the forceps extraction is planned, the lens is supported against depression and dislocation by the pressure backwards of the hook applied just off the limbus. This same amount of pressure is maintained with the hook while the lens is moved from side to side gently and firmly to break the zonula below. As soon as the zonula is broken and the lens dislocated, the lens is extracted in the capsule with the forceps and the hook, depending upon the procedure which is routine with the operator.

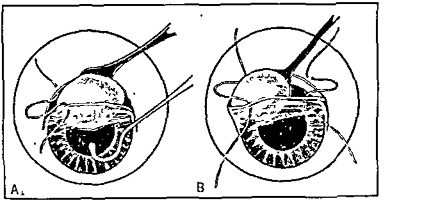


Fig. 451.—The maneuvers of intra-capsular extraction *A*, the completion of the Knapp procedure; *B*, the lens is being moved toward the side of the corneal-scleral incision line by means of the broad spatula This is to be assisted with the curve and tip of the hook.

Continuing the grasp on the capsule, according to Kalt's procedure, the lens is carried out of the corneo-scleral incision with the hook constantly following behind. The lens will present in a large number of cases with its lower pole foremost, actually a tumbling maneuver. Thick hypermature lenses, however, will be delivered in the shape of a bulbous pear, apex of this in the grasp of the capsule and with but little adjustment in its shape to the shape and the width of the corneo-scleral aperture. Harder, flat, and sclerosed lenses will present without tumbling and with their long axis almost constantly parallel to the plane of the iris.

In Knapp's technique for extraction, as soon as the dislocation of the lens is achieved, the grasp on the capsule forceps is released, the forceps laid aside, and a broad spatula or lens spoon is held with the right hand agains the posterior lip of the wound, depressing this somewhat. The actual delivery of the lens results from the pressure of the hook on the

[1] Trans Am Acad. Ophth. and Otolaryng, 1934, and Am. Jour Ophth., Ser. 3, vol. 17, August, 1934.

cornea below the lens transmitted through the vitreous, combined with the depression of the posterior lip of the wound. Some folding of the cornea behind the lens is obtained, but for this direct form of delivery it is always less in amount than that necessary for the Smith-Indian tumbling extraction (Fig. 451, *A*).

If the Smith-Indian extraction is being done, the broad spatula is used at the posterior lip of the wound more to steady the eye than for any other reason at this moment. The hook is used with its blunt tip directed backward, but not toward the optic nerve; instead the force applied is directed toward the ciliary body. The limbus here is actually indented and at the same time the hook, point as well as curve, is moved from side to side to rupture the zonula. The operator knows that this has occurred when the lower pole begins to rise out of the pupillary aperture. The direction of force is now changed, though without release of pressure on the eyeball because, if this is permitted, the lens will simply sink back into its former fossa. As the lower pole of the lens lifts, the cornea is indented immediately beneath it, swinging the lower pole of the lens up and toward the corneoscleral aperture. When the lens approached the mid-point of the cornea, the tip of the hook is used less, and one begins to use more of the curve. At this time the cornea is folded behind the lens, and one may somewhat depress the posterior lip of the wound. If everything continues uneventfully, the lens is actually stroked from the wound with its zonula above still intact and adherent. One is very much aware of the intact zonula above because of the great deformity which occurs in the iris above as the lens passes through the pupil, lifting the iris with it because of the unbroken suspensory ligament hinge. As soon as the lens is actually out of the anterior chamber, it is swept from the lips of the wound by the concave curve of the hook carrying it to one side (Fig. 451, *B*).

Regardless of the type of extraction carried out, as soon as the lens is free from the anterior chamber, the corneo-scleral wound should be immediately closed with the sutures which had been introduced. Their ends are cut short, and the toilet of the wound is carried out. If the iris or the pillars of the iris in the case of an iridectomy have receded into the anterior chamber, additional sutures can be inserted and tied. With a complete iridectomy, this is the usual procedure. If the extraction has been done instead through an intact pupil, the iris should be replaced with the iris repositor as the next step in this toilet of the wound. A prolapsed iris is an invitation for prolapse of the vitreous, and if the iris is immediately replaced, the support which it gives to the vitreous at the angle may prevent this. Even if complete reposition is not obtained at this moment, sufficient should be achieved so that the pupillary margin is near to where it should be. The additional necessary sutures are introduced, and with these in place and tied, one can continue with the toilet of the iris sphincter or the iris pillars until they lie in their normal positions. At times when the iris sphincter or the pillars of a coloboma refuse to return to a natural level, one will find that stroking the cornea with a moistened sponge or patting it near the limbus will dislodge incarcerations or folds and permit satisfactory reposition. The last step of the operation is to pass the iris spatula between the lips of the wound throughout its entire length so that one is certain that no capsule or fibers of the zonula are incarcerated. One end of the bridle suture is cut, and this withdrawn, and the eyes closed.

The indications for an imperative loop extraction are fortunately not common. These indications in general are connected and have to do with the delivery of a dislocated lens. (1) The dislocation itself may be the primary cause for the surgery; (2) the other indications are those related with the presentation of vitreous before the extraction; (3) dislocation of the lens but without the loss of vitreous; and (4) difficulty of extracting the lens within a capsule after its dislocation and before complete engagement has occurred within the corneo-scleral incision.

In some of these instances the capsule may have torn, or the hold of the capsule forceps become loosened before tearing, or the lens be so large in size that the usual incision is proving inadequate. The order of these as just quoted is probably the inverse order of a necessary loop extraction, *i. e.*, the first mentioned demand the loop, while the last mentioned can be assisted appreciably by the use of the loop.

Frequently, Morgagnian and hypermature cataracts extractions are quite uneventful, others prove to be quite complicated affairs Intra-capsular extraction is often difficult; at times the capsule is so taut that no forceps will hold. For these, suction cup extraction is ideal. In other instances the lens is reduced to a flabby bag of semifluid content, and in these the capsule tears quite readily. If an extensive capsulotomy has been done, anterior chamber irrigation will probably give a clear black pupil. In some it is permissible to fish for the capsule after the extraction, using smooth capsule forceps and thereby converting the case into an intra-capsular extraction. Many of these hypermature lenses dislocated very readily; even the bit of trauma which is present and which is connected with a corneo-scleral incision may result in their dislocation, and when the iridectomy is done, one can see that the lens is actually dislocated and movable. In such instances, the loop should be used immediately for the extraction. The Smith-Indian extraction is also satisfactory in other cases.

In the insane the major portion of cataracts are hypermature lenses. Because of the patient's mental state, almost all of this surgery is done under intravenous evipal anesthesia. Because of the absolute relaxation which this gives, it is almost routine to extract these, after the iridectomy, with the loop and the hook. The Smith-Indian technique also lends itself well to such hypermature cataracts, even those with so much degeneration that they have become Morgagnian in type

Postoperative Procedures.—The immediate postoperative treatment, in the operating room, is the instillation of a 1 or 2 per cent solution of atropine into the cul-de-sac of all eyes that have had a complete iridectomy, or of 1 per cent eserin, as an ointment or in solution for those cases operated through an intact pupil. (Before these solutions or ointments are instilled, the operator should be certain to cleanse both superior as well as inferior cul-de-sacs from any sheds of capsule or clots of blood which may lie there.) The lid sutures are then tied in a single bow knot, the excess lengths cut off, both eyelids of both eyes anointed with a 1 to 3000 bichloride or sulfa drug ointment and a bilateral Barraquer dressing applied. This consists of the application of a thin film of wet cotton to the lids. As this is patted into shape, it approximates closely the curves and depressions of the lids. Tiny fluffs of dry cotton are then heaped upon this so that all depressions are filled in smoothly with a nicely rounded convex dome. As this dressing dries, it immobilizes the lids very satisfactorily. Double eye pads are

placed on top of the mound of cotton and these are fastened to the face with strips of adhesive or court plaster. The operated eye is then protected from blows with some type of metal shield. A black cloth bandage or a stiff Ring mask is usually quite welcome in addition, in that it further assists in eliminating all light from the operated eye. In general, it is not necessary to apply a roller bandage to adult patients, though children and patients who might be considered to become unruly, after the operation, should have this additional safeguard.

Regardless of the operation which has been done, the writer feels that no patient who has had an intra-ocular operation should be permitted to walk from the operating table to the bed. Naturally, if the surgery has been done under general anesthesia, this factor does not enter, nor is it an issue with those men who routinely operate their cataract cases in bed. The practice has been observed, however, and the author cannot agree to its advisability or necessity. If the case is under general anesthesia, those rules connected with the recovery of a patient from a general anesthetic apply here. The patient must be most carefully watched until reaction from the anesthetic is complete. Fortunately, the recovery from avertin anesthesia is slow and quiet and quite similar to awakening from a sound sleep. If an emotional upset is present, or the patient is inclined to be restless or unruly, a tie or restraining sheet, across the chest of the patient to the sides of the bed, will prevent grave consequences. Too much restraint, however, must be resisted unconsciously or involuntarily by the patient. Certainly sufficient precautions must be exerted to safeguard the operation, but the amount necessary is a factor individual with each patient.

Postoperative sedatives depend upon the amount of pain and the discomfort present. Morphine is definitely contraindicated. Codein may be used hyperdermically if necessary. In general, however, the barbiturates are sufficient. Many patients complain bitterly of pain in the back. This is especially present with elderly patients. After the first twenty-four hours, considerable relief can be given for this by turning the patient toward the non-operated side and supporting his or her shoulders and chest toward that side with pillows. Elevating the knees with a pillow will also assist. Elderly patients, especially those with cardio-vascular and myocardial conditions, are susceptible to hypostatic pneumonia. Temperature, pulse, and respiration must be carefully watched in these cases, and their positions changed frequently, even at hourly intervals, not only by moving them from side to side, but also by raising and elevating the head of the bed to varying degrees.

Occasionally elderly male patients with hypertrophied prostates have difficulty in urination. This should have been discovered prior to their operation, and if there is any possibility of retention, an indwelling catheter should be placed prior to the operation and retained until the patient may be permitted to leave his bed. It seems that the presence of this is less productive of cystitis than the repeated catheterization which would be necessary otherwise. It is not uncommon for some retention to be present in both male and female patients after the operation, and it is quite proper to catheterize them at twelve-hour intervals for two or even three times if this is necessary.

Abdominal distress is common from gastro-intestinal fermentation plus the inactivity of the patient. This can be kept to a minimum if the post-

operative cataract diet discussed in Chapter I is adhered to. Elevating the head of the bed one or two notches may give relief, introduction of a rectal tube may be necessary, and hot turpentine stupes applied to the abdominal wall also seem to assist. Prostigmin methylsulfate is most valuable to prevent as well as to relieve abdominal distention. It may prevent the necessity for Wangenstein gastric tubes, otherwise indicated in paralysis of the small bowel. If the condition becomes alarming, it may be necessary to use a high enema, though in general enemas are contraindicated for the first forty-eight hours after the operation. At this time, usually, it is permissible to give a mild cathartic at bedtime and to order an enema for the following morning.

In all cases, except those with unusual or extraordinary indications, the first dressing is done forty-eight hours after the operation. The outside dressings are removed, the adhesive lifted from the face, and the patients warned, however, not to pinch their lids together because this is a rather natural response to the pull of the adhesive. The molded cotton is peeled from the lids and the unoperated eye first opened and cleansed of secretions by irrigation with a quiet stream of warm boric acid solution. Before the lids of the operated eye are opened, the dressing should be inspected for the presence of blood, and the upper lid carefully scrutinized for swelling and discolorations. These signs, if present, mean a certain amount of postoperative cyclitis. The closed lids are sponged free of adherent secretions, the lid sutures untied, and the patient told to open. At this time, the patient should be protected from any great amount of illumination. The illumination used must be adequate so that the dressing can be properly done, but it should not be directed toward the patient's eye. Pulling on the upper lid with the suture may cause pain and a reflex spasm of the orbicularis; therefore, the upper lid must be lifted, if at all, with the thumb above the orbito-palpebral fold. The lids need not be opened more than an amount sufficient to see if the anterior chamber is formed and that the postoperative condition is satisfactory. It is not necessary to inspect the suture line at this first dressing unless one suspects an iris prolapse. With care, the upper lid can be lifted sufficiently and the illumination directed into the superior cul-de-sac so that this fact may be known. In doing this dressing, the patient should be warned against looking down and against squeezing the lids together. Neither are necessary for the dressing, and each may be the cause of later complications. The cul-de-sac is then cleansed with warm boric acid, atropine instilled either as a solution or as an ointment, the suture removed from the lower lid margin, the lids closed, and the loop of suture in the upper lid margin pasted to the cheek with a tiny piece of adhesive. If the anterior chamber is formed and there is no iris prolapse, it is usually possible to permit the unoperated eye to remain uncovered. If there is any doubt about the matter, however, and especially if one of the two just mentioned is present. the anterior chamber is not formed, or if the iris tends to prolapse then both eyes should be again closed. Another reason for closing both eyes is seen occasionally in rather nervous old people who constantly work their lids in an exaggerated winking. In these cases it is better to continue binocular occlusion for at least twenty-four to forty-eight hours more.

The uneventful case should be dressed daily thereafter. Patients who have had eserin instilled postoperatively should have their pupils opened

widely as promptly as is possible; in other patients the primary dilation must be maintained. (See Complications.) The average patients may be permitted from the bed on the fifth day, at first for a half hour in the morning and a half hour in the afternoon. Thereafter this can be increased until, by the tenth day, they are spending as much time as they wish out of bed. Bathroom privileges are usually extended on the sixth to the eighth day, depending upon the case. These periods of increased physical activity are always dangerous, in that the exertion connected with them may result in rupture of the corneo-scleral wound, even though the gaping is only subconjunctival, in iris prolapse, and in anterior chamber hæmorrhages. The nurse must prevent the patient from bending over and from straining, either with an enema or at the stool.

The conjunctival sutures may be removed as soon as the patient can coöperate readily without straining. Usually they will loosen and fall out between the eighth and tenth day, but occasionally it is necessary to take them out at this time. As soon as the sutures have been removed, black glasses are to be worn, and hot compresses and atropinization to be used several times a day until the eye is white. The patient can be discharged from the hospital at any time after the tenth day. Here again, however, certain factors are of importance. It is a much better plan to keep a patient in the hospital under active care than to permit him to return to a hotel room dependent more or less upon his own efforts. As soon as the eye is white, the atropine may be omitted, and when the pupil has returned to its minimum size, the necessary glasses may be ordered.

CHAPTER XX

COMPLICATIONS OF CATARACT SURGERY.

THE complications, which are possible, following a cataract extraction are the greatest in number for any type of surgery regardless of the realm of surgery in which the technique may lie. The antomical parts which are concerned are all small and sometimes minute. The manipulations necessary are delicate; the mechanics which underlie some of the complications are beyond the control of the patient or the operator; the necessity of depending so much upon the patient's good behavior and absolute cooperation during the operation as well as during the period of postoperative recovery and convalescence; and last, is the close relationship which exists between the eye and the patient's general physical condition. Jackson,[1] in discussing complications and the late results of cataract surgery emphasized several points, relevant not only to complications, but also of importance in obtaining maximum success from the surgery. These included postponing the correcting aphakia lenses until a fair amount of time has elapsed after the operation in that too early use of an operated eye, postoperatively, is detrimental; there was but a little difference in the visual results of intra-capsular and extra-capsular extractions, all other things being equal, considering naturally that the pupillary aperture is not occluded by an opaque capsule; and the longer that one can wait between bilateral cataract extractions, the better for the patient, in that in these cases the eye operated first gave ultimately the better results; he also emphasized the immediate postoperative care of a patient with asthma, emphasizing the importance of keeping the patient sitting up in bed as it is usually easier for him to breathe in this position.

The complications in general may be divided into two classes, those which are immediate and connected with the technique of the procedure, and those which occur later and are more generally connected with the postoperative convalescence of the patient.

IMMEDIATE OR EARLY COMPLICATIONS

1. Movement of the eye before the section has been completed.
2. Completion of the section within the cornea or in the region of the ciliary body.
3. Wounding the capsule and perforating or engaging the iris with the cataract knife, or even completing an iridectomy.
4. Inability or disinclination of the patient to look down.
5. Orbicularis spasm.
6. Expulsive extrusion of the lens, or dislocation of the lens with the completion of the corneal section.
7. Partial and complete iridodialysis.
8. Vitreous prolapse before, or after the extraction.
9. Persistent prolapse of the iris, and retroversion of the iris.

[1] Trans Sec. Ophth., Am. Med. Assn , Session 1937.

10. Posterior dislocation of the lens into the vitreous, and recession of the lens into the anterior chamber.
11. Retained nucleus and cortex.
12. Immediate subretinal or choroidal hæmorrhage.
13. Air in the anterior chamber.

THE LATER COMPLICATIONS

1. Conjunctivitis and intra-ocular infection, (nutritional changes in the cornea).
2. Atropine conjunctivitis and dermatitis.
3. Late subretinal or choroidal hæmorrhage.
4. Postoperative delirium.
5. Striped keratitis.
6. Delayed closure of the wound.
7. Hyphemia.
8. Continued pain.
9. Iris and vitreous prolapse, incarceration of the iris, drawn up pupil.
10. Detachment of the choroid.
11. Filtration chemosis.
12. Spastic entropion.
13. Iritis and iridocyclitis.
14. Sympathetic ophthalmia.
15. Late rupture of the wound.
16. Secondary or capsular cataract, the organization of fibrin and exudates with the development of a pupillary membrane.
17. Cystoid cicatrix.
18. Diabetic complications as diabetic coma or insulin shock, anterior chamber hæmorrhages.
19. Separation of the retina.
20. Postoperative glaucoma.
21. Epithelial proliferation.

Discussion of These Complications.—If the patient should move the eye before the section has been completed, one of two things will happen; either he will pull the knife out of the eye or it may result in completing the section through the cornea at a more or less oblique angle. If the knife has been withdrawn without damage, the patient should be quieted, a conjunctival flap prepared by sharp dissection with scissors and forceps, and the section completed at the corneo-scleral junction line with sharp scissors, curved on the flat. The scissors should have a blunt tip to the blade which enters the anterior chamber so that it will glide over the iris without wounding it, or become incarcerated in its stroma. If the incision has been made in the cornea, there is nothing to do except to complete the operation. In these instances, however, one must be certain that the pillars are free of the corneal incision so that anterior synechiæ will not occur. In some of these cases, a sliding flap should be prepared and sutured over the line of the corneal incision. An incision within the cornea is always short and will have to be lengthened so that an adequate extraction aperture is obtained. If an intra-capsular extraction is achieved in these cases the results will be much more satisfactory. The incision in the neighborhood of the ciliary body or even at the root of the iris results usually from a faulty counterpuncture. It should never occur from the initial puncture as this is always

under better visible control. Edema of the conjunctiva and difficulties with fixation are the reasons for a faulty counterpuncture. One knows this has occurred because of the distance from the limbus at which the point of the knife appears through the conjunctiva, the sudden loss of the anterior chamber, and the extensive hæmorrhage which occurs. The complication need not be fatal to the eye, and can be corrected in part before the section is completed. The edge of the knife should be turned forward very slightly, the knife fixed at the point of puncture, as a fulcrum, and the cutting edge at the tip made to sweep up toward the limbus until the correct position has been reached for completing the incision. The hæmorrhage from the wound must be staunched before continuing with the operation, and tight conjunctival sutures should be used at the end of the operation.

Gross astigmatism is perhaps as common following faulty section as it is connected with faulty healing. The faulty section results in healing of the section in an offset sliding position, that is, the two lips of the wound are offset one from the other, folding the cornea at one extremity of the incision. The gross astigmatism which follows delayed healing is quite a different thing, for in this last, the upper part of the cornea is actually tipped forward in its entirety, and in such instances the astigmatism is quite regular.

Opening the capsule with a cataract knife makes it necessary to proceed with capsulotomy lens extraction. One should not, however, be satisfied with this amount of capsulotomy. A toothed capsule forceps must complete a capsulotomy to the necessary size. If the iris is engaged with the cataract knife either after the puncture or at the time of the counterpuncture, the knife can be very slightly withdrawn, disengaged, and the section then completed. The blade should be withdrawn from this engagement, however, with the iris before the point has completely perforated it; otherwise there will be a ragged cut in the iris. That complication of the iris falling in front of the cataract knife has already been discussed in adequate detail.

At times the patient has great difficulty in coöperating. One cannot extract the lens satisfactorily unless the patient is looking, at least, straight to the front. A forced downward rotation may result in gaping of the corneo-scleral incision line, and invites vitreous prolapse. When operating under a general anesthesia, the position of the eyeball is nicely controlled with a bridle suture. The practice, however, of having an assistant hold the eye down with forceps is not recommended.

The control of an orbicularis spasm is a problem which the assistant must handle. The patient should be quietly warned and should be told to open his opposite eye, the pull on the lid relaxed a bit, and the action of the occipito-frontalis controlled by the third and fourth fingers on the eyebrow, these being used to lift the eyebrow and to immobilize it at the bony orbital rim. It is rather likely that the posterior pull of the four recti muscles is responsible for more cases of vitreous prolapse than is spasm of the orbicularis. On the other hand, a sharp and sudden spasm of the orbicularis after the corneal section will cause expulsive and precipitant extraction of the lens. This is occasionally seen so marked that the lens actually shoots from the eye. The consequences of this are always serious since the amount of vitreous which is expelled at the same time is usually so great that the eye will go on to phthisis bulbi, even if an immediate subretinal or choroidal hæmorrhage does not occur.

Occasionally, especially in patients with hypermature lenses, one discovers that the moderate trauma connected with the corneal section has resulted in rupture of the zonula, though the vitreous is still intact. One may try the extraction of these lenses with smooth capsule forceps if a satisfactory grasp of the capsule can be obtained, but usually the loop should be used in such instances for extraction. In the presentation of vitreous before the extraction has been started (*i. e.*, the zonula has not only ruptured but also the hyaloid) the loop must be used without any choice.

Vitreous prolapse which occurs after the extraction is especially distressing, because the essential part of the operation has actually been completed uneventfully. The assistant must immediately release his hold on the bridle sutures, if the patient is under avertin, the lid be lowered somewhat and lifted away from the eyeball, depressing at the same time the lower lid. If the patient is being operated under local anesthesia, the same maneuver applies to the lids, and the patient is told to look upward. The lid elevator should be removed for a few moments, and the lids closed. After a minute or so, the lid elevator can be introduced again, and the conjunctival sutures tied with the eyeball in upward rotation. The bridle suture is then turned over to the operator himself, and he himself can depress the eyeball sufficient for the introduction of an iris spatula, for cutting off the vitreous which is lying between the lips of the wound, and for the introduction of necessary additional sutures. In general, prolapse of the vitreous after the extraction means that the operative manipulations must be terminated as soon as is possible, but not to close the eye abruptly abandoning it to a providential destiny. Cazelis,[1] in 1923, in discussing vitreous loss mentioned as essentials: a stage of repose for the mutilated organ; an effort to save the eye by exact suturing of the wound; safeguarding the function by freeing the pupillary aperture to the point of a black pupil and by regulating the position of the iris; last, assurance of cicatrices by prolonged binocular bandages even to six or eight days. If the case has been operated with an intact pupil, the operator may try a complete iridectomy before closing the eye. The fibers of the vitreous as they come through the pupillary aperture toward the corneo-scleral section will drag up the iris and evert it, invite iris prolapse and iris incarceration, and may be the cause of an intractable iritis. The handling of vitreous prolapse after the extraction must be modified with each individual case. It is essential to remember the treatment, to know the possibilities and complications which can result therefrom, and to complete all operative manipulation as promptly as is possible. Attention to this last statement has saved more eyes than have all of the other fussy, complex, and detailed manipulations together.

Persistent prolapse of the iris before the extraction makes an iridectomy imperative. It is usually impossible to replace an iris satisfactorily once it has prolapsed. A peripheral iridotomy may be sufficient, but a complete iridectomy is usually necessary. A partial or complete iridodialysis may occur when the iridectomy is being done. The two reasons for it are: (1) the patient moves the eye while the iris is in the grasp of the forceps; and (2) the operator removes the forceps with the contained iris therein without sectioning completely the iris with the iridectomy scissors. Nothing can

[1] Clin. Ophth., Paris, 12, 312, 1923.

be done for a complete iridodialysis except the wearing of pin-hole glasses afterward. The eye may be lost through glaucoma. Incomplete or partial iridodialysis is more common. After the lens extraction, it is quite possible to stroke the iris back into the angle to such an extent that one would be unaware of this complication after healing has occurred.

Retroversion or an involution of the iris is seen occasionally after intracapsular extractions through an intact sphincter, and after vitreous loss. It seems that the contraction of the vitreous, as it recedes into the scleral shell, folds the iris back upon itself simultaneously into a retroversion. In those instances with an intact sphincter, the edge of the iris, at the point where the retroversion lies, should be grasped with an iris forceps and a minimal iridodialysis performed. Then the bridge of iris may be withdrawn from the anterior chamber and a complete iridectomy done if it cannot be replaced. The same complication happens occasionally late during the convalescence; also in those cases wherein some vitreous has been lost. The contraction of the vitreous still present is undoubtedly the cause for it.

A bubble of air occurs in the anterior chamber, not uncommonly, when the flap is being lifted for the introduction of the capsule forceps. It would have no clinical significance were it not for the fact that this air may be laden with bacteria. It should, therefore, be removed forthwith. An iris spatula can be used to separate the lips of the wound, and the bubble may be forced out by stroking upward on the cornea with a moistened sponge. If this does not occur promptly, an anterior chamber irrigator should be used. Frequently it seems to accompany collapse of the cornea. The operator might wait a moment or two before proceeding with the operation when this collapse occurs. In general, it is a good sign, and indicates normal intra-ocular tension without a tendency for the vitreous to drive forward the diaphragm of the lens and its suspensory ligament. These cases are very satisfactory for intra-capsular extraction.

Dislocation of the lens into the vitreous as an intercurrent complication demands an intra-capsular extraction with the loop, and has been discussed.

The retention of the nucleus and of any great amount of cortex is dangerous. A grave iridocyclitis may result. Ophthalmitis phacoanaphalactogenica may develop, and either of the two cause the loss of the eye. If a nucleus fragments during a capsulotomy extraction, it is necessary to use smooth forceps for each individual portion. A non-fragmented nucleus can sometimes be stroked from the anterior chamber, at other times irrigated (as is done with a fragmented nucleus) or removed with the lens loop. As much of the cortex as can be removed must be removed by hook and spoon, by stroking the cornea, by irrigation, with its adherent capsule, by the careful use of a smooth capsule forceps. Those cases which are complicated by presentation of the vitreous are a serious difficulty, in that so little can be done without increasing vitreous loss. The stirring up of vitreous, retained nucleus, and of cortex to an emulsion is not conducive to satisfactory postoperative results.

Subretinal or choroidal hæmorrhage which appears at the operating table usually follows loss of vitreous. It is disheartening and means the complete loss of the eye. One is faced with the problem of doing an immediate surgical evisceration or of putting a dressing on the eye, sending the patient from the operating room, and doing the same thing later. From the medical-legal standpoint, if the patient is being operated under local

anesthesia, perhaps the best thing to do is to obtain his consent immediately and proceed forthwith the evisceration. If under avertin anesthesia, however, it is necessary to obtain this consent specifically after his recovery from the initial procedure and then carry it out thereafter. In the final analysis, this matter of subretinal or choroidal hæmorrhage is largely connected with the prophylaxis of, or the prevention of, its occurrence. It is an accompaniment of more or less extensive vascular pathology, results from the abrupt changes which occur in the intra-vascular and extra-vascular pressures, subchoroidal or supra-choroidal—and when it appears the prognosis is absolutely hopeless.

Later Complications.—Conjunctivitis and subsequent intra-ocular infections are fortunately not common. General surgeons have repeatedly expressed amazement at the impunity with which the ophthalmologist opens the eyeball and continues therein and thereon without consequent infection. The conjunctival sac is not sterile, but it must have a remarkable immunity toward pathogenic organisms. Preoperative cultures are important, and no surgery is to be done in the presence of pyogenic bacteria. Closing the eye, as one does dollowing a cataract operation, forms a very satisfactory culture tube for any bacteria which may be therein. Collins[1] calls attention to this as well as to the favorable circumstances for an increase in the growth of bacteria due to the temperature of the body, the lack of movement of the eye, and the decreased secretion of the tears. In postoperative conjunctivitis the surgeon is concerned naturally with the possibility of this infection continuing into the anterior chamber. It is rather likely that most cases of postoperative intra-ocular suppuration are extensions from the cul-de-sac, though Butler[2] said, "in my opinion an inflammation which develops in the first three or four days is exogenous but one which has developed after the seventh day is endogenous in its origin." Further, he feels that the postoperative infections are more apt to occur in diabetic patients than in the non-diabetic cases. The pneumococcus is probably responsible for the largest number of these complications, though the Staphylococcus aureus and the Streptococcus, hæmolytic and non-hæmolytic, are also found.

If at the time of the first dressing there is a postoperative conjunctivitis present, the dressing should not be replaced. A culture must be taken immediately; (though one should not delay treatment for this report) hot sterile compresses ordered; copious irrigations with warm boric acid solutions or with warm normal saline used at hourly intervals or sufficiently often to keep the cul-de-sacs free from pus; and a 1 per cent silver nitrate solution instilled several times a day and this neutralized with normal saline thereafter. A freshly made solution of argyrol in 20 to 35 per cent strength is probably also a satisfactory bactericide. Its virtue, however, lies largely in the fact that it is a heavy solution and causes precipitation and coagulation of the bacteria. The mercury preparations of metaphen, mercurophen, and mercurochrome are very satisfactory for irrigations as well as for instillation. The sulfa drugs, as solutions of sodium sulfathiazole, aqueous solution of neoprontosil, and microcrystals of sulfathiazole, have all replaced these earlier preparations with outstanding benefit. The condition may remain limited to the conjunctiva, and if so, it should

[1] Trans. Ophth. Soc. United Kingdom, 34, 18, 1914.
[2] Trans. Ophth Soc. United Kingdom, 40, 181, 1920.

clear up rather promptly, though it may, as Clapp said, prolong the convalescence many weeks. Frank intra-ocular infections are occasionally seen as already established at the time of the first dressing. Herpes ophthalmicus has been seen and also non-herpetic indolent ulcers which will result in a loss of the eyball if these cannot be checked. Intra-ocular infections usually end in panophthalmitis. Occasionally the eyeball is saved and some vision returned by a discission or iridotomy of the organized exudate. These instances are not common, and the infection must have been limited to the anterior segment of the eye Everyone who has examined the stained microscopic slides of an eye lost from postoperative panophthalmitis, will know that nothing could have saved that eye under examination. The vitreous body is filled with pus, that portion of the vitreous still present is infiltrated with polymorphonuclear leukocytes, and the retina is infiltrated, detached, and contracted. This factor of postoperative infection is one of the best reasons for the routine practice of dressing a cataract forty-eight hours after the operation.

TABLE 1—SULFA DRUGS

	Sulfanilamide	*Sulfathiazole*	*Sulfadiazine*
Absorption	Rapid and uniform	Most rapid of the three	Rapid and uniform
Distribution	All body fluids	All body fluids except cerebrospinal fluid	All body fluids
Local action	As prontosil	In sodium salt solution, although caustic with continued use	As microcrystals
Excretion	Rapid	Less rapid	Slow
Cyanosis	Very common	Uncommon	Rare
Fever	Frequent	Common	Rare
Liver damage	Frequent	Rare	Rare
Kidney damage (hematuria)	Rare	Less rare	Rare
Anemias	Occasionally too frequent Leukopenia most frequent	Rare to occasional leukopenia	Rare

TABLE 2—SULFA DRUGS

Sulfanilamide	Hemolytic streptococcus Gonococcus Virus conditions, as trachoma (?)
Sulfathiazole	Staphylococcus Gonococcus Pneumococcus Bacillus coli Bacillus pyocyaneus
Sulfapyridine	Pneumococcus Bacillus pyocyaneus
Sulfadiazine	Staphylococcus Streptococcus Gonococcus Non-hemolytic streptococcus Pneumococcus

If an infection has started and is discovered at this early period, there is still hope for the eye. The treatment necessary is both local as well as general. The sulfa drugs are rapidly coming to the fore as a most valuable adjunct in the treatment of postoperative infection. Table 1 and Table 2, which follow herewith,[1] should be considered. Ethyl hydrocupreine should be used in a 1 per cent solution at regular intervals if the culture reveals the

[1] Spaeth, E B. The Résumé of the Sulfanamide Drugs in Ophthalmology, Penna. Med. Jour., March, 1943.

presence of a pneumococcus. A 1 per cent solution of hexylresorcinol has been recommended. Subconjunctival injections ought to be given daily, of Pregyl's iodine solution, or of 1 to 5000 cyanide of mercury solution, injecting 8 to 10 minims at a time. The mydriatics should be forced to keep the pupil dilated as much as is possible. Foreign proteid therapy is indicated in the form of milk proteids, diphtheria antitoxin, or intravenous injection of typhoid autitoxin. Sodium salicylate must be given by rectum in that gastric distress may follow the large doses which are indicated. Stargardt[1] recommends a débridement of all soft tissue in the incision, washing out the anterior chamber with 1 to 5000 cyanide mercury (oxycyanide of mercury) continuing with the daily drainage or paracentesis of the anterior chamber and if a capsule sac has been retained he attempts to remove it. Ellett[2] has reported favorably upon the application of a 12 per cent solution of magnesium sulphate as an eye bath for five minutes at two-hour intervals. With corneal complications especially, pneumococcic forms in particular, irrigation of the lacrimal sac and the application of tincture of iodine, trichloracetic acid and the actual cautery are indicated, in addition to that treatment already outlined. A paracentesis of the anterior chamber through a non-involved portion of the cornea may be indicated in these instances as well. Recovery has resulted following spontaneous perforation of the cornea in such instances, an experience also noted by other observers.

Too frequently the sulfa drugs are used with rather haphazard dosage and without the repeated necessary blood checks demanded for maximum medication. Ocular conditions in which the sulfa drugs are indicated should have the maximum dosage unless that is not tolerated. If the patient reacts to the drug even with only hyperpyrexia, a rash, or with cyanosis, lesser amounts than the maximum dosage are of little value. Hence the optimum blood level of the drug being used should be maintained, *i. e.*, 15 mg. per cent for sulfanilamide, 8 to 10 mg. per cent for sulfathiazole, and 8 mg. per cent for sulfadiazine. Daily blood level determinations are necessary even with non-hospitalization. Watching improvement in the condition being treated is a very poor criterion for deciding upon an increase or a decrease in the amount of the drug being taken. If the condition being treated requires the sulfa drug the sooner the saturation point in the body fluids is reached and maintained the sooner will the condition improve; then, and not before, is a decrease in the amount of the drug permissible. There is little danger in maintaining blood levels too long with medication, but definite danger is connected with too early cessation of the drug. Healing may cease at that point and a rather unfortunate reactivation occur in the disease process.

Nutritional changes in the cornea are quite different from the striped keratitis commonly seen. In the latter, white lines appear, with oblique illumination, radiating in a fan-shape from the edge of the corneal incision. Occasionally other ones cross these at a right angle. They are due to folds in Descemet's membrane, and will recover ultimately. The nutritional changes mentioned are a bit different. These seem to occur in patients who had previously had a uveitis, hence, may be expected following the extraction of complicating cataracts. There is an accompanying iritis, but

[1] Ztschr. f. Augenh., 43, 321, 1920.
[2] Jour. Ophth. and Otolaryng., 10, 227, 1916.

this may be secondary and consequent rather than the reverse, because iritis and iridocyclitis are also seen with but few corneal changes. The cornea is dull and is infiltrated and there are blotchy deposits on the posterior surface of the cornea quite different from the usual punctate keratitis of an iridocyclitis. The iris becomes dull and an organized exudate bridges the pupil. Frequently there is considerable uveal pigment present in this membrane. The treatment of these cases is rather similar to the local and the constitutional treatment for frank infection, even though these patients will have negative bacterial cultures. Foreign proteid therapy is strongly recommended, and in addition to the mydriatics, one should use the higher strength solutions of dionin, even to the use of powdered dionin. These cases demand drastic treatment, and if any results are to be obtained, the treatment must be continued for quite some time.

The presence of a notched pupil, especially in intra-capsular cases, usually means the adhesion of strings of vitreous which have passed through the pupillary aperture and are adherent to the corneo-scleral incision line. Wright[1] calls attention to this, in that a notched pupil should be examined with the corneal microscope to distinguish between a point of peripheral anterior iris synechiæ, and a thread or band crossing the pupil edge. While the former may be left alone, the latter should be divided at an early time with a knife needle, since it is liable to set up recurring irritation.

Atropine conjunctivitis and atropine dermatitis of the skin of the lids are not really uncommon. Occasionally, the preoperative examinations will reveal the patient's idiosyncrasy to this drug, at other times the operator is not aware of this idiosyncrasy until the time of the first dressing Naturally the atropine should be stopped and some other mydriatic used. The lids should be kept well anointed with a boric acid ointment The dressing should be removed three or four times a day and the cul-de-sac irrigated with warm normal saline solution. The condition is of no consequence if properly diagnosed and properly treated.

The question of expulsive subretinal and choroidal hæmorrhage has been considered in part under the immediate and early infections. It also occurs later during the convalescence of the patient. The outstanding symptom is the tremendous pain which occurs immediately. This is accompanied by chills and temperature. The wound bursts open and blood pours from the wound, carrying with it all of the vitreous and the retina. An impending subchoroidal hæmorrhage, *i. e.*, one which has not as yet burst the corneoscleral incision line, can probably be stopped by an immediate and prompt posterior sclerotomy and the drainage of the subchoroidal and subretinal spaces in this manner. This applies especially to those rather rare cases of subchoroidal hæmorrhage which occur at the operating table, while instruments are still at hand for the immediate treatment of this. Various men have recommended different forms of treatment for this complication. Usually, however, the damage is done before any form of treatment can be instituted. Those cases of hæmorrhage into the anterior chamber and hæmorrhage through the vitreous which appears in the coloboma of the iridectomy can be frequently saved. A firm pressure dressing should be applied and hæmostatics injected subcutaneously or intravenously without delay, as adrenalin, ergot, and thromboplastin. The patient should

[1] Am. Jour. Ophth., Ser. 3, vol 20, March, 1937.

be quieted with morphine and treatment outlined for the accompanying arterial hypertension. In the final analysis prevention is of outstanding importance in these instances. Ziegler[1] recommended the use of sodium nitrite and venous section as well as the retrobulbar injections of novocain and adrenalin. This latter can *only* be of value in preventing the expulsive hæmorrhage which occurs at the time of the surgery. Weihmann[2] called attention to the fact that higher altitudes predispose to this complication and recommended surgery on arteriosclerotics at an altitude more nearly sea level. Gross and Fromaget[3] operated an eye successfully in an individual who has lost his first eye by expulsive hæmorrhage, by first trephining the case and then later extracting the lens. An unchecked expulsive hæmorrhage must be followed by an evisceration, and the sooner it is done the earlier will it be possible to discharge the patient from the hospital with a comfortable socket.

Postoperative delirium is seen especially with the aged. Clapp[4] discusses in detail the classification presented by Frankl-Hochwart[5] for this. Four types are recognized: (1) The hallucinatory insanity in non-alcoholics; (2) the simple mental confusion of senile patients; (3) delirium in alcoholics; and (4) inanition confusion. Greenwood[6] quotes the incidents of postoperative delirium as from 2.5 to 3 per cent of all cases. It is rather interesting that the author who has operated on many insane patients at a large psychiatric institute has found that the incidence of postoperative delirium is not an increased factor with these individuals. It is quite possible that this is due to the fact that these patients are all well narcotized and usually held for the first three or four days under large doses of the barbiturates. Chloral and the bromides are of no value once the condition is established, for gross damage may occur before these medicines can be effective. Patients who have been in the habit of using alcohol must be given this as regularly, after the operation, to prevent withdrawal delirium. Many of these cases clear up promptly if the unoperated eye is uncovered and if some well known friend or member of the immediate family is available to assist in calming their anxiety and quieting the distressing and disturbing confusion which comes from their strange surroundings. The delirium itself has no serious clinical importance except in those cases of hallucinatory insanity and the acute delirium of the alcoholics. The importance of the complication rests in the damage which the patient can do to his operated eye while delirious.

Delayed closure of the wound and the non-formation of the anterior chamber are rather commonly seen. With intra-capsular extractions the operator need not be concerned at all with any possible serious consequences as long as he keeps the pupil open with a mydriatic. Delayed reformation of the anterior chamber in the presence of an intact sphincter is a bit more serious, and one may have to use glaucosan to open the pupil against the contraction of the eserin which had been instilled at the time of the operation. This same condition when found in the presence of a capsulotomy operation will oftentimes make one suspicious of the retention, within the

[1] Contributions to Ophthalmological Science, 1926.
[2] Klin. Monatsbl. f. Augenh., 78, 43, 1927.
[3] Ann. d'ocul., 153, 476, 1916.
[4] Cataract, Its Etiology and Treatment, Lea & Febiger, p. 228, 1925.
[5] Jahrb. f. Psychiat., 9, 122, 1890.
[6] Trans. Sec. Ophth. Am. Med. Assn., p. 233, 1928.

wound, of some capsule remnants. To guard against this one should be certain to sweep an iris spatula the full length of the wound as one of the last maneuvers before closing the lids. Zentmayer, in a personal communication, spoke of a case wherein the reformation of the anterior chamber was delayed until the eighteenth day, without any consequences whatsoever. Restlessness, squeezing the lids, and coughing may all be factors in continuing it. It is quite possible that the rather common choroidal detachments which follow intra-ocular operations may be a factor in this. The author has repeatedly seen shallow anterior chambers continue until a complete recovery has occurred from this interesting and not always unimportant finding. Some of these cases of delayed healing are followed by a marked hypotony, especially in the aged, though the same condition is seen elsewhere, perhaps almost as frequently and without any explanation available for it. Atropine and dionin must be continued and it seems as if retrobulbar injections of from 1 to 5000 cyanide of mercury have been of assistance in some of them.

The removal of sutures from the corneal-scleral incision line following healing is not without danger. Many patients, when the time comes for this procedure, between the fifth and the eighth postoperative days, have photophobia, with some sensitivity, and much manipulation is quite impossible. The sutures should not be grasped in a forceps prior to cutting A sudden upward tug by upward movement of the eyeball may result in rupture of the wound, at the worst, or an anterior chamber hæmorrhage at the least. The eyeball should be cocainized, the upper lid lifted with the lid elevator in one hand and with the loupe magnifier worn, and under good illumination, one point of sharp-pointed scissors is to be introduced from below into the loop of the suture. It can then be cut with safety. If the patient should look up unwittingly, or because of lack of coöperation no danger can occur before the suture is cut in that the loop of it will simply be pulled away from the point of the scissors. This applies especially to the cutting of the corneal-scleral sutures as placed according to the Verhoeff, Stallard, or McLean techniques.[1]

Hæmorrhage in the anterior chamber which remains following the operation absorbs rather promptly. Hyphemia, however, which develops later, for some reason, never absorbs as rapidly; probably because the trauma which occasioned it continues in existence. It is seen in diabetics, in nephritics, in the presence of low-grade iritis and iridocyclitis, with gaping of the wound, and following frank traumatisms to the eye. It occasionally follows after a routine dressing and is initiated by pain which may last three to six hours. In many cases the blood cells sediment to the lower levels of the anterior chamber and remain there for quite some time. In those instances, the aqueous has a yellow tint, the iris looks brassy, and one may find blood cells and blood pigment lying in grooves and folds on Descemet's membrane. The importance of a late hyphemia rests in the fact that the fibrin present may result in an organized exudate bridging the pupil. Therefore, midriatics should be pushed, dionin used for absorption, with hot compresses, calcium, and iodides both indicated, and thromboplastin should be used subcutaneously if necessary. The presence of pain which is unusual or which develops during the night after a trauma, after a

[1] Hilding, A. C., Arch. Ophth., 24, No. 2, 371, August, 1940.

dressing or when the patient first is permitted from the bed, is rather likely due to a more or less extensive anterior chamber hæmorrhage.

An iris prolapse, when present, is usually seen at the time of the first dressing, though it is not uncommon to find this barely present at that time, increasing, however, in extent from day to day. This is sometimes accompanied by a later vitreous prolapse driving the iris forward. Vitreous prolapse, which has occurred at the operation, may continue after the first dressing, demanding cauterization. The repair of iris prolapse has been discussed in detail under iris surgery. It is sufficient to repeat here that reparative surgery for this must be done as soon as it is discovered. Incarceration of the iris, *i. e.*, stationary iris prolapse, is to be corrected if it is increasing size, or if it is without aqueous filtration. An incarcerated iris plus filtration need not be disturbed. Cases are seen wherein late secondary postoperative glaucoma developed in one eye, and not in the other, due to a definitely filtering incarceration of the iris. A non-filtering incarceration can usually be corrected by wiping it off with the actual cautery. If this is unsuccessful, it should be treated surgically by resection, into the anterior chamber, and with a van Lint sliding flap as one would treat any postoperative iris prolapse. Repeated cauterization of the iris in an iris prolapse is to be condemned. A single application of the actual cautery in any type of minimal prolapse may be permissible, but to repeat it is simply inviting sympathetic ophthalmia. (See Section on Iris Prolapse, Chapter XVII.)

Rather recently Allen[1] discussed in greater detail many of the post-operative complications of serious importance in connection with cataract surgery. A major portion of his discussion on the treatment of iris prolapse follows immediately herewith. As a teaching ophthalmologist he is very much aware of the fact that iris prolapse is too common as a complication and too frequently is rather poorly handled. Because of this, and because of the excellence of Allen's contribution, it follows herewith almost verbatum:

Once a prolapse occurs, it should be recognized and notations of its first appearance made upon the record. I (Allen) am not inclined to touch it for nearly a week unless it occurs within forty-eight hours as I wish the wound to be as firmly healed in the rest of its extent as is possible. At the end of a week, depending upon its size and whether or not it is covered with conjunctiva, the treatment begins. If it is a small prolapse and covered entirely with conjunctiva after anesthesia with pontocaine the prolapse is touched with a very small applicator dipped in trichloracetic acid. This treatment is repeated daily for a week, then three times a week for two weeks. It is remarkable how many of these prolapses will flatten out under this treatment without further complications.

Larger prolapses and those not covered with conjunctiva have to be handled surgically. As a rule we do not spend enough time planning our course of action and to get complete anesthesia when the operation is decided upon. One must be exceedingly delicate as the tissues are very thin and undue haste or pressure will cause disastrous loss of vitreous. The part must be thoroughly anesthetized by retrobulbar and subconjunctival injection as well as topical application. This anesthetization is decidedly more difficult than at the time of the first operation. Unless the eyeball is soft before it is opened, vitreous will present as soon as the prolapsed iris is cut. Therefore in the retrobulbar injections enough adrenalin must be used with the anesthetic to cause a tension of −1 to the fingers within ten minutes. We wait until that softening occurs before opening the wound.

[1] Allen, Thomas E., Management of Ophthalmological Surgical Complications, Clinical Congress of the American College of Surgeons, Boston, November 3 to 7, 1931.

Some sort of a conjunctival flap must be prepared before the prolapse is excised This can be a sliding flap or a simple cowl. Sutures must be placed in the corneal and/or the scleral tissues. If one bears in mind the histological relationship in a case of prolapse he will better understand how to handle the situation. A prolapse means that there is very little tissue between the contents of the eye and the outside world. At the edge of the prolapse the cornea and/or sclera are shelved to almost infinitesimal thinness. If the prolapse is large one cannot expect adequate protection with only a conjunctival flap. It is essential to have the edges of cornea or sclera meet in such a way that they will grow together firmly, to withstand the postoperative intra-ocular tension. This may be aided by doing a cyclodialysis immediately after the prolapse is excised. Canthotomy will relieve postoperative pressure from without; this is imperative in the so-called "squeezers"

The actual excision is best preceded by a very light cautery, either chemical or thermal, of the epithelial structures that cover the prolapse and the nearby tissues for *at least* 2 mm. beyond the prolapse. When the eyeball is thoroughly softened and after the conjunctival flap is prepared, one should carefully dissect down until the iris is reached at the root on both ends and on the scleral side of the prolapse The iris is then grasped and an attempt made to free it very delicately from the *corneal* adhesions. This can usually be done with the fine forceps but occasionally a spatula is necessary. The prolapsed iris should be pulled away from the adhesions to both distal and proximal edges and carefully excised so that the part remaining will retract. The corneo-scleral edge is then very carefully prepared with the scissors so the sutures will cause an exact approximation of the two edges Interrupted fine silk sutures on small corneal needles are placed perpendicular to the wound to hold the edges together and make it watertight; they penetrate only the anterior layers of the stroma. The sutures are then drawn up to demonstrate this and before being tied, their ends are passed through the conjunctival cowl. The sutures should be tied snugly but not so tightly as to invert or evert the edges.

A late rupture of the wound is usually traumatic if not caused by an expulsive hæmorrhage. Even though a single traumatism may be slight, this may have happened several times. Regardless of whether or not accompanied by an iris prolapse, that portion of the corneo-scleral wound which is ruptured should be uncovered after the surgeon has prepared a sliding van Lint flap. The lips of the wound are then to be sutured to the episcleral tissue with very fine silk sutures and the conjunctival flap brought down across the limbus to cover these. In extensive ruptures it is wise to cauterize the two lips of the wound with actual cautery, lightly, before the corneal-episcleral sutures are tied. Any iris prolapse or vitreous prolapse which is present at the same time must be cleanly resected. Iris prolapse, which has been present and untreated, may at times pass on to a huge limbal staphyloma, so marked that extensive surgery is necessary to save the eye and to prevent inevitable secondary glaucoma. The surgery of this was discussed under limbal staphyloma (section of Surgery of the Cornea, Chapter XVI). Figure 452 shows such a case, with the triangle indicated for resection from the cornea, *B*, the sutures for the sliding conjunctival flap and the corneal suture; and *C*, the immediate postoperative result.

The importance of iris and vitreous prolapse is not the low grade subacute iritis which may intervene (this will recede usually) but the fact that so many of these are followed, in later months, by a slow, progressive haziness of the cornea. This starts from the site of the adhesion and the incarceration and spreads forward across the cornea. Wright[1] in discussing the effects of even simple herniation of the iris alone, as he says:

Quite apart from the added trouble of a vitreous adhesion or compound hernia, unless reduced without impactions and incarcerations, or permanent extrusion of

[1] Am. Jour. Ophth., Ser. 3, vol 20, March, 1937.

uvea through the lips of the deep wound may be followed by: (1) immediate irritability and quiet iritis; and (2) late recurring irritability and iritis. The impaction may result in a weak fistulous scar, sometimes of a bulging or staphylomatous type, which renders the eye susceptible to recurring inflammatory attacks. This is more likely if the prolapse is not covered with conjunctiva, as may well be when it occurs near the angle of the section where a mere marginal flap of conjunctiva is present. (3) Late septic infection. This, I (Wright) believe, deserves at least as much attention as that given to late infection after trephining, since we see probably as much of one as the other. We consider that it is associated with exposed iris and a weak scar, and hence we try to cover irreducible iris herniæ; (4) secondary glaucoma. This complication need hardly be discussed in detail. Sometimes a filtering scar tends to stave it off. It is a graver problem than the secondary glaucoma due to anterior adhesions in an eye from which the lens has not been removed. It may be dealt with by a decompression below, of a Lagrange type; and (5) sympathetic ophthalmia. Sympathetic ophthalmia, in our experience, is uncommon.

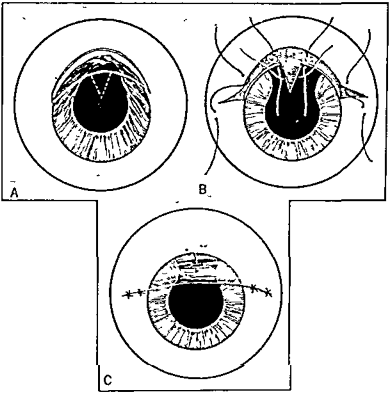


FIG 452.—Limbal staphyloma. *A*, showing the position for triangle resection of the cornea; *B*, sutures in place, *C*, completed.

We have seen it, or what we took to be sympathetic ophthalmia, as a complication of cataract extraction, but so rarely that we do not bother about it. An interesting thought here is that we may possibly see less trouble of this sort because we are very apt to give our patients large doses of aspirin or the salicylates, when we become aware that the uvea is involved in the section, or otherwise disturbed, or there is any evidence of uveitis or ill-defined irritation whatsoever. I (Wright) have seldom seen the classical massive sympathetic ophthalmia in Indians, and the milder varieties that have been observed behave more like allergies than infections under treatment.

In discussing the treatment of these conditions, Wright's various procedures are as follows:

Intravenous neosalvarsan, intramuscular bismuth (sometimes Donovan's solution and potassium iodide by mouth). Serum (anti-diphtheritic, or other available

horse serum) 15 cc. daily for a week and continued according to the patient's reaction. First test for hypersensitivity and if necessary desensitize. Iodine intravenously, a solution of 6 grains of iodine and 6 grains of potassium iodide to an ounce of water is used in 20 minim doses. Sodium salicylate, 1 grain per pound of body weight. Sodium bicarbonate is given with this Deep intra-orbital cyanide-of-mercury injections 1/2000 up to 5 minims, combined with an equal part of novocain. Foreign protein-milk injections intra-muscularly, or T. A. B. vaccine subcutaneously or intravenously. Blue pill at night followed by a saline purge in the morning Leeches, atropine, dionine, adrenalin.

Detachment of the choroid is an interesting condition, but it has no clinical significance. If one examines cases of intra-ocular operations routinely, early after the surgery, a large number of cases will show this complication. O'Brien[1] called attention to this rather recently. The detachment has a peculiar grayish color, shows large bullous masses, is present without fluctuation, and the retina follows smoothly over the choroid. It may appear in any portion of the retina and may be so extensive that as one looks into the fundus he sees nothing except a gun-barrel-like tube directed toward the posterior pole of the eye. It was common formerly to restrict activity, but it seems the cases recover even more promptly when permitted the usual postoperative routine.

De Long[2] feels that the term "detachment of the choroid" is a misnomer. He showed, by microscopic sections correlated with the ophthalmoscopic findings, that so-called detachment of the choroid is rather likely, in the largest percentage of instances, a massive choroidal and subretinal edema. In representative cases, the choroid becomes tremendously thickened, the lamellæ widely separated with a hydrops so extensive as to lift the retina at times almost a centimeter in elevation. He (De Long) considers the condition as the result of interlamellar choroidal edema from capillary transudation of serum. The promptness with which the condition develops as the result of pressure changes, extra- and intravascular (capillaries), and its slow but inevitable spontaneous recovery are quite consistent with this conjecture. It is not to be confused, however, with subchoroidal hæmorrhage. This latter complication must be corrected surgically by scleral paracentesis and the release of the hæmorrhage, before it breaks through an operative wound.

Filtration chemosis may assume alarming proportions at times, for one knows that the corneo-scleral incision, beneath the conjunctival flap, is gaping. The condition fortunately is not frequent. The conjunctival flap curves over from the limbus in a large grayish bleb, for the upper half of the cornea is tilted forward in a highly astigmatic position. Atropinization should be pushed and a snug pressure bandage applied until this recedes. The bleb may be punctured with the actual cautery and then touched with a 2 per cent silver nitrate solution. Ultimately these cases will need a high cylinder in the aphakia lenses.

Spastic entropion occurs only in the presence of conjunctivitis or iritis or iridocyclitis. Ordinarily, one can control it with two slightly diverting strips of adhesive holding the lower lid downward. The condition may continue until the etiological factor is corrected. An external angle canthotomy will relieve it if lesser procedures are unsuccessful, but it cannot be allowed to continue because of the irritation which it causes.

[1] Trans Am Ophth. Soc., 1936
[2] Trans. Phila. College of Physicians, 1939

Anterior chamber epithelial cysts are occasionally seen following cataract extraction. Their treatment is difficult. Kerby has reported some success in the treatment through the use of sclerosing fluids injected into the cyst cavity. Vail separately evacuated the cyst with the needle of a hypodermic syringe passed into the cavity of the cyst. He washes out the cyst very lightly with a weak iodine solution being careful not to rupture it through these manipulations, then in turn evacuates all of this iodine solution (1 per cent solution of tincture of iodine).

Iritis, iridocyclitis, Descemetitis, and ophthalmitis phaco-anaphalactogenica are similar conditions though with different etiological factors. Butler feels (see Postoperative Conjunctivitis, Chapter V) that any infection which occurs after the seventh day is endogenous in origin. It is rather likely that all cases of iritis and iridocyclitis fall within this classification, hence the necessity for the preoperative eradication of all possible foci of infection, to prevent iritis and iridocyclitis. Diabetics and nephritics seem to be especially prone to this complication. Ophthalmitis phaco-anaphalacto-genica is likely allergic in nature, due to sensitization of the individual from the retained lens proteid. Verhoeff and Le Moine,[1] and Burky and Woods,[2] Gifford and others, are quite certain of this. Instances connected with the lens proteid of a traumatic cataract or of a capsulotomy extraction must be desensitized by the subcutaneous injection of increasing doses of a lens proteid extract. The usual extract is a 2 per cent solution, and the maximum dose is from 2 to 2.5 cc. In all cases of iritis, atropinization must be pushed to its maximum; in addition, hot compresses, the injection of foreign proteids, large doses of salicylates, and mercury inunctions all seem to assist toward recovery. Low-grade iridocyclitis, following a cataract extraction, in a certain percentage of instances continues to or ultimately proves to be a sympathetic ophthalmia. Fortunately the complication is rare, even more so after cataract surgery as compared with its incidence from perforating injuries of the eye in the region of the ciliary body. Hambresin[3] analyzed 11 such instances. Clapp[4] quotes him as follows: "he (Hambresin) advises against interference with a prolapse of the iris, either with knife, scissors, or cautery, if the prolapse has existed for three days, because of the danger of sympathetic trouble developing." In all of these instances, iridocyclitis ophthalmitis phaco-anaphalactogenica, and sympathetic ophthalmia, the treatment is in general the same; atropine, hot compresses, subconjunctival injections of cyanide of mercury, of Pregyl's iodine solution, or of physiological saline solution, sodium salicylates in large doses by rectum, pilocarpin sweats, elimination by the bowels and the kidneys, foreign proteid therapy and desensitization by lens proteids and uveal pigment if the patient is positive to these. Clapp feels that an interdermal tuberculin test should be also made, in that a latent tuberculosis lesion may be activated following an operation; and if this is found positive, treatment by tuberculin should also be instilled. If inflammation develops in the opposite eye one may have to do an enucleation of this primarily inflamed eye to prevent further damage to its mate.

The complications of an after-cataract, a secondary capsular or membranous cataract, a drawn-up pupil, and the presence of iris synechiæ to

[1] Trans. Internat. Cong. Ophth., p. 234, 1922.
[2] Arch. Ophth., 6, 548, 1931.
[3] Bull Belge d'ophth., 57, 107, 1928.
[4] Cataract, Its Etiology and Treatment, Lea & Febiger, 1934.

the hyaloid or to cortex, are conditions which must be corrected surgically. They all impair vision and invite secondary glaucoma.

These complications are usually connected with retained capsule and cortex, as a result of organized exudate in the pupillary membrane from iritis and iridocyclitis, follow a drawn-up pupil, and are the result of repeated hæmorrhages in the anterior chamber after the extraction—seen most commonly in diabetics. The surgery of these is not unlike that surgery which must be carried out, in later years, for epithelial proliferation. Further attention will be paid to this later. Occasionally, one finds it necessary to do a discission for retained capsule and cortex remnants following a capsulotomy operation before the eye has quieted wholly from the reaction of the original operation. However, the procedure should be delayed, if possible, until the eye is absolutely white, for then it is much less painful, the possibility of stirring up a secondary iritis is lessened, and the insult to the vitreous (which must accompany many discissions) will be far less serious in its end-results. A membrane of any type which prevents maximum vision should be incised or removed. The slit lamp and the ophthalmoscope are both necessary for diagnosis and for determining the type of surgery which is to be done. One can estimate the density of the membrane, the course of its major tension fibers, the thickness and rigidity or flaccidity of the membrane, the presence and amount of synechiæ, the condition of the iris pillars, the depth of the anterior chamber, and the condition of the iris stroma itself, for these all are factors, which modify the surgery. The operation, it must be emphasized, is not a trivial procedure. It has the same potential dangers as any other operation in which the eyeball is opened. An iridocyclitis, which will go on to phthisis bulbi, may develop, and vitreous damage may result in contraction of the vitreous body so that retinal separation will develop later. The procedure demands hospitalization and as careful preoperative and postoperative observation and technique as did the cataract operation itself.

Alexander[1] discussed in detail this matter of after-cataract. The points which he stressed should be well known, and are of great importance In the absence of infection he feels that retained cortex seldom causes iritis except in cases of hypermature or other forms of degenerated lenses, though as he said, Smith and Holland are contrary minded to this. If the anterior capsule has been well removed from the pupillary aperture the rate of absorption of retained cortex in the aged is as rapid as that seen in the young. Irrigation of the anterior chamber cannot be depended upon to remove all of the retained cortex, though it will probably remove the major portion, preventing a subsequent (and consequent) rise in ocular tension. Alexander stated that he has repeatedly found a large amount of cortex present in the aged, even as late as the age of eighty-four years.

The primary and essential factor in the formation of an after-cataract is the persistence, in the pupillary aperture, of sheets and strands of anterior capsule. Incarcerated within these are the remains of cortex and of hæmorrhage, but the presence of the capsule itself is the serious factor. It is for this reason that Elliot recommended after-irrigation of the aqueous chamber (Alexander), pulling away all strands of capsule floated up by forceps, as those of Holth's, or preferably, similarly shaped forceps having no teeth.

[1] Trans Ophth. Soc. United Kingdom, vol. 50, 1930.

Three major procedures are at our command: (1) discission with a sharp knife needle as the Ziegler or the Wheeler types; (2) capsulotomy or iridocapsulotomy discission with a de Wecker scissors; and (3) capsulectomy.

Discission.—*Discission with a sharp knife needle is indicated in instances* with a fine spider-web like membrane, some cortex may be incarcerated in the fibers of the membrane, but cases with extensive cortex remnants must be handled differently. The presence of multiple synechiæ, with or without a shallow anterior chamber, is a contraindication; also cases which were preceded by iridocyclitis must be handled differently. Cases with a tendency to secondary ocular hypertension should be operated with the de Wecker scissors, especially if the membrane is fairly dense. Deformity of the pupil with incarceration of the iris may be corrected with

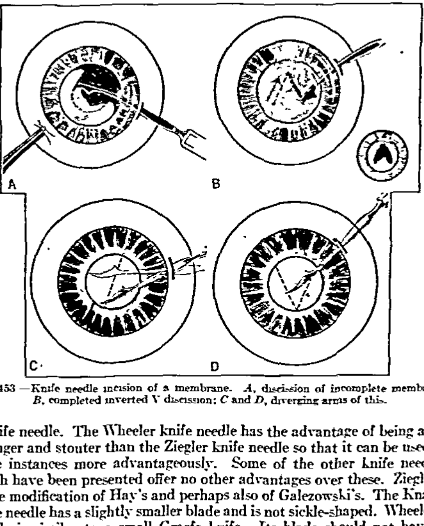


Fig. 453—Knife needle incision of a membrane. *A*, discission of incomplete membrane; *B*, completed inverted V discission; *C* and *D*, diverging arms of this.

a knife needle. The Wheeler knife needle has the advantage of being a bit stronger and stouter than the Ziegler knife needle so that it can be used in some instances more advantageously. Some of the other knife needles which have been presented offer no other advantages over these. Ziegler's is the modification of Hay's and perhaps also of Galezowski's. The Knapp knife needle has a slightly smaller blade and is not sickle-shaped. Wheeler's needle is similar to a small Graefe knife. Its blade should not have a breadth of more than 1 mm. nor a length greater than 16 to 18 mm. Colonel H. Smith is very much against the use of a sickle-shaped knife needle. According to Alexander, he states that a sickle knife is a sort of infernal machine; and that no instrument maker can sharpen properly a knife with a concave edge. Smith prefers a small cataract knife in good order. Dis-

cissions with stout "stop" needles used for tearing an opening in the membrane are not recommended. The end-results do not confirm the advisability nor the advantages of the procedure.

Figure 453 illustrates the direction which the edge of the knife needle is carried in the discission of a membranous after-cataract. The knife needle is held between the first two fingers, the thumb or small finger resting upon the patient's face, the eyeball fixed with the opposite hand, and the needle introduced into the anterior chamber (under maximum atropine dilation) with the blade parallel to the surface of the iris. The point of entrance may lie in the cornea at the limbus or 1 mm. posterior to this in the sclera. The position of the point of entrance naturally depends upon the direction of the fibers of the membrane in that maximum opening is achieved parallel to the line of the cut. The center of rotation for the cutting arc is the point of entrance of the knife needle. In general, the usual place will be temporally and somewhat above or below the horizontal meridian of the cornea. As soon as the point appears in the anterior chamber, the handle is depressed until the point arrives at that place where it is to be plunged into the membrane. This place should be at an upper or lower extremity of the proposed discission line. The handle of the knife needle is then turned so that its cutting edge will be directed in the correct position for incising the membrane; the point of the needle is then thrust quickly into the membrane and immediately followed by the cutting motion upward or downward as the case may be. A to-and-fro sawing movement is necessary at the same time the handle is depressed or elevated. The membrane should not be torn nor pulled open. Sufficient of it, however, must fold upon itself on the edge of the knife so that it can be cut. This applies especially to the loose and often freely-floating after-cataracts. The edge of the knife must be sharp, otherwise the fibers will simply stretch and follow the course of the knife but will fail of bisection. Occasionally denser bands may be found, offering great resistance, so that they cannot be cut. It is an unfortunate finding, but in such instances it will be necessary to incise above and below such bands and permit them to remain intact.

At the completion of the sweep of the knife needle, the operator will find it often necessary to twirl the handle of the knife somewhat so that the cutting edge will always be at its point of maximum possible efficiency. As soon as the incision is completed, the knife needle is brought to its *original position, that is with its blade on the flat and parallel to the* plane of the iris, and then withdrawn with a quick jerk. Aqueous should not be lost at the entrance or the exit of the needle.

Duverger[1] uses a similar technique with similar instruments, but prefers a vertical instead of a horizontal slit, calling attention to the fact that with a vertical slit a very slight narrowing of the palpebral opening converts this capsulotomy into a satisfactory stenopeic aperture.

Many membranes are more complete than that illustrated in Figure 453, *A*. In such instances, Ziegler's inverted A capsulotomy must be done. Figure 453, *B*, illustrates this. The needle has been introduced in the line of 1, *D*, thrust into the membrane above and an oblique inclined arm cleanly cut downwards. As soon as this incision is made, the needle is brought to its original position, carried further across the anterior chamber, its edge turned downward and the membrane transfixed at a point simil

[1] Arch. d'ophth., 38, 449, August, 1921.

to the lower end of the first incision. The handle is now carried upward, the cutting edge downward, to meet the first of the two incisions somewhat below a potential apex at which these two converging cuts would meet. As a result, a tongue of membrane is cut, hinged above. This tongue should retract of itself a great amount so that an inverted triangular opening results. If it does not retract sufficiently the point of the knife needle may be used to fold it back upon itself, enlarging thereby the resulting opening. The knife needle is then withdrawn as before. Knapp[1] made a similar incision, though his completed incision was crucial, the first cut being horizontal and the second passing from above down, or from below up to it. Kuhnt[2] modified it somewhat by making his incision H-shaped, that is, with two major horizontal incisions parallel one to the other, these being connected by a shorter one at their mid-line.

After the operation atropine is again instilled and the eye dressed. After twenty-four hours if everything is satisfactory, the dressing may be removed and further atropine and hot compresses utilized to relieve the very moderate postoperative reaction which develops.

The complications to a discission have already been mentioned (page 610). Escape of aqueous may be so extensive as to lose the anterior chamber. It may even be necessary to postpone the operation. In passing the knife, the blade must go directly through the cornea, as an oblique position within the cornea will hamper the free movements of the knife handle. This is probably the best reason for a scleral entrance. If the iris is incised or damaged, hæmorrhage may occur. Haab first, and subsequently several others, mentioned that a thread of vitreous will occasionally adhere to the knife needle and follow it through its exit in the cornea, and be responsible for the subsequent development of an adherent leukoma. The vitreous should be resected and the point of exit of the knife needle lightly touched with cautery so that the adherent vitreous will release within the anterior chamber. Török and Grout[3] feel that this complication will not occur if the entrance of the knife needle lies in the sclera. The complication may be the cause of iridocyclitis and even wound infection. Atkinson[4] does a posterior capsulotomy immediately after a combined capsulotomy extraction because of clouding of the posterior lens capsule late after extracapsular extraction. The practice is not concurred in, for the complication does not occur frequently enough to risk damaging the vitreous at the time of the initial operation, and if subsequent surgery is necessary, the discission may be done at that time with no greater danger and certainly with more ease and with equal satisfaction.

The most important complications to a discission are usually not immediate. They include: (1) secondary glaucoma, (2) iridocyclitis with a later phthisis bulbi, and (3) late retinal separation due to vitreous contraction. The prevention of these depends almost wholly upon the manual dexterity of the operator, his regard for the tissues of the eye and the vitreous, and in his abstaining from tugging and pulling upon an adherent iris or ciliary body.

Iridocapsulotomy.—The second of the procedures mentioned is iridocapsulotomy. This means the sharp incision of a membrane or of the iris

[1] Trans. Am. Ophth Soc., 8, 297, 1898.
[2] Ztschr. f. Augenh., 1, 151, 260, 1899.
[3] Surgery of the Eye, Philadelphia, Lea & Febiger, 1923.
[4] Am. Jour. Ophth., Ser. 3, vol. 17, June, 1934.

with a membrane. A capsule punch or the de Wecker scissors are the two instruments to be used. This type of operation is indicated in membranes that are too dense for a discission with a knife needle; in the presence of multiple synechiæ, either anterior or posterior; with an atrophic iris impregnated with cicatrix; in the presence of post-inflammatory pupillary membranes; and with gross disturbances in the shape and the position of the pupil. It is also indicated in those cases which are complicated by or with a tendency to secondary glaucoma. It should not be done in the presence of chronic iridocyclitis, with ocular hypotension, with ocular hypertension, or in those instances where light perception and projection are so poor that the end-results are quite in doubt. Further, this operation should never be done before the eye has wholly recovered from any previous operative procedures. Some of these procedures have already been discussed under surgery of the iris (Chapter XVII). Figure 454 illustrates 4 cases in which vision was conserved by reason of an iridocapsulotomy; the illustrations emphasize the hopelessness of these cases without surgery, as compared

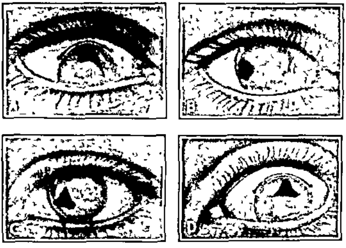


FIG 454.—*A*, 6/9 vision; *B*, full working vision, *C*, can recognize people across the street, *D*, 6/20 and can read newspaper print. (Atkinson)

to the satisfactory result from surgery. *A*, with correction had 6/9, minus vision; *B*, with correction, sufficient vision "that he has been able to attend to his duties on the farm in a normal manner"; *C*, with correction "a degree of vision which enables her to do the housework for her family, to recognize friends across the street, and to thread a large darning needle"; *D*, with correction at distance 6/20 and with the near add is able to read news type.

Franceschetti[1] calls a similar procedure korepraxy. A keratome incision is placed below, and with an iris hook, the edge of the retracted iris above is engaged and pulled downward toward the keratome incision. That portion of the iris which is thus prolapsed, is resected giving, in many instances, a central pupil with coloboma pillars not unlike a normal uncomplicated iridectomy. The danger of causing recurrence of the primary iridocyclitis is not to be forgotten, and this should be combated.

There is one danger to be seriously considered in those cases wherein there is a second eye, healthy and normal. It is the possibility of sympa-

[1] Klin Monatsbl. f. Augenh, 103, 459-466, October-November, 1939.

thetic ophthalmia in the opposite normal eye. Therefore, further surgery must be carefully considered to decide whether iridocapsulotomy is to be done, an enucleation, or no surgery at all. As enucleation is to be considered only as a last resort, it is wiser not to operate, if the other eye is normal, should the case be such that there is a possibility of sympathetic ophthalmia developing.

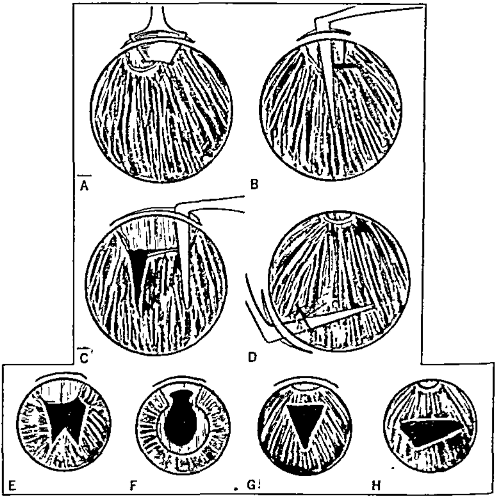


Fig. 455 —Irido-capsulotomy. *A*, introduction of keratome and incision of capsule and membrane, *B*, first cut with de Wecker scissors, *C*, section; *D*, transverse cut with de Wecker scissors *E*, *F*, *G*, and *H*, artificial pupils obtained in various cases by iridocapsulotomy.

A keratome is passed into the anterior chamber at the limbus but not so far back on the sclera that the conjunctiva is pierced. The point of the keratome should then make a slit in the capsule membrane. If there is necessity present for a conjunctival flap, this should have been prepared beforehand. The keratome is then withdrawn and the de Wecker scissors passed into the anterior chamber, one blade in front and the other behind the iris, through the slit in the membrane made by the keratome. The jaws of the pince-ciseaux are then closed, as in Figure 455, *B*, and the first cut made. The scissors are then withdrawn, reintroduced at the other extremity of the limbal incision, and the second cut made. With the first

incision, the handle of the scissors is elevated slightly, while with the second it is depressed slightly so that the membrane is cut in the plane of maximum efficiency for the scissors. As with the inverted A-shaped discission of Ziegler, the tongue of capsule and iris incised should retract downward, giving a roughly quadrilateral-shaped pupillary aperture. If it does not retract, it may be necessary to cut a third time, removing the major part of this tongue of iris and membrane obliquely, giving a pupillary aperture somewhat the shape of E. It is a mistake to grasp this tongue of iris and capsule with iris forceps and to resect it *ab externo*. Occasionally, in the presence of a dense capsule and without a deformed or drawn-up iris, a single central cut will be sufficient directly through the middle portion of a dense and thick capsule. It is also quite possible to make the cuts, especially in those cases of markedly drawn-up pupil, so that the base of the triangle is upward and the apex downward. It is quite permissible in such cases to prolapse the tongue of iris which has been incised, and to remove it at its base, with de Wecker scissors, *ab interno*. Such a procedure should be called probably iritoectomy rather than iridocapsulectomy. In some cases there is no pupil whatsoever. In these instances the iritoectomy should be performed through a keratome incision at the limbus from the side, and the de Wecker scissors cut made across the traction lines of these drawn-up fibers. A pupil should result therefrom, essentially satisfactory in all details. If the incision should be made parallel to these drawn-up fibers, an unsatisfactory linear slit will result. More than one cut, when passed across such taut fibers, is seldom necessary.

A capsule punch is advantageous in the correction of a distorted iris with a drawn-up pupil. After the incision has been made in the membrane, the capsule punch is inserted with its jaws closed. One jaw of the punch is passed through the incision in the membrane, with the other blade behind the membrane. It is then carried down across the membrane as far as possible (depending upon the size of the corneal incision), the blades closed, by pressure upon the handles, and the instrument withdrawn with the punched-out piece of membrane within its jaws.

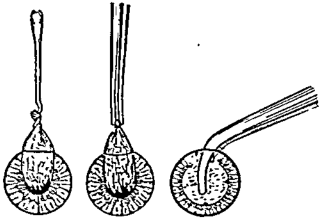
The capsule punch demands a considerably larger keratome incision than one would ordinarily make; for this reason several men have devised a combination keratome and capsule punch. Clapp describes the use of these instruments: "The point of the punch is made to penetrate the cornea with the jaws closed, after which they are opened and the instrument advanced until the membrane is pierced. The jaws of the punch are now closed, thus removing a section of the membrane, after which the instrument is withdrawn."

There are other ways of using the de Wecker scissors in these dense membranes. The facts present in any one case modify the technique naturally. Mayou made two parallel incisions in the membrane, with the keratome: a larger upper and a smaller lower; and then resected the bridge of membrane between the two. Wilmer used for iridocapsulotomy, especially in cases where there was a completely occluded pupil, a prearranged conjunctival flap, a short limbal incision above, and a straight cataract knife incision longitudinally across the contracted fibers of the iris; and through this carefully carried-out horizontal incision he continued with the de Wecker scissors resection of any amount of iris tissue desired.

An iritoectomy can also be done with a cataract knife. The point of

entrance for the section should lie in the cornea at the limbus. As soon as the point appears in the anterior chamber some of the aqueous is permitted to drain from the eye, the point of the knife is then plunged through the iris or the iris and capsule membrane, carried across to a similar point in the membrane at the opposite limbus. There the membrane is again penetrated, this time, however, from behind it. The counterpuncture is completed and the corneal section finished. In this way a horizontal cut is made through the membrane as the cataract knife completes the corneal section. The de Wecker scissors and especially the punch are then used as described. The advantage of the von Graefe knife section lies in its adaptability to puncture and counterpuncture, and the possibility of sectioning anterior synechiæ at the same time, especially when these lie toward the periphery of the cornea.

The postoperative treatment of these procedures is a bit more exacting than that necessary for a simple discission. The possibility of stirring up old iridocyclitis is always present; therefore atropinization and hot compresses should be started as soon after the operation as is possible. Salicylates may be indicated, and the use of foreign proteid therapy is to be carried out as an almost routine procedure.



A B C

FIG 456 — After-cataract A, capsulectomy with hook; B, capsulectomy with smooth capsule forceps; C, capsulectomy with Panas forceps (After Török and Grout)

Complete capsulectomy is indicated in those cases of dense membranes, often with the retention of considerable cortex. The presence of synechiæ is a contraindication unless these can be broken down. It is the ideal procedure following a capsulotomy extraction of an immature complicating cataract. Fluid vitreous is a contraindication, as is ocular hypotension. The two probably go hand in hand. The pupil should be dilated *ad maximum* to determine the presence of synechiæ and for ease in extracting the membrane in its entirety. In the open operation for after-cataract, the release of all synechiæ is one of the most important factors, these to be broken with a blunt hook or with an iris repositor without damage to the ciliary body. It is permissible to do an iridectomy or to increase the size of one present, so that complete release of all adhesions will be obtained.

A keratome incision should be of good size; the membrane itself is not

to be pierced or injured in any way. The major portion of the aqueous will probably be lost with the withdrawal of the keratome.

Either a sharp hook or a capsule forceps is used. The sharp Tyrrel hook is introduced through the keratome incision to the lower part of the pupillary aperture, and there the point made to embed itself, as in Figure 456, well into the dense capsule, and the zonula ruptured below by a to-and-fro movement. When this has occurred, the capsule is withdrawn as a flaccid deflated sac, from below upwards, by steady traction upon the sac as well as by the continuation of the to-and-fro movement of the hook within the sac. The hook must be on its flat as it passes through the incision, so the sharp point will not become engaged in the lips of the wound

The capsule forceps should be of an untoothed type, for a toothed forceps will lacerate the capsule and prevent its satisfactory extraction. Of the various types of forceps, the Kalt with rather large cups and the Elschnig capsule forceps have seemed to function the best. They are passed down across the anterior chamber in the same method, as if one were doing an ordinary intra-capsular lens extraction. A firm hold is obtained of the capsule at its lowermost part, the zonula ruptured there, and it is then slowly withdrawn with the same to-and-fro movements as in Figure 456, *B*. To prevent tearing of the capsule and its incomplete extraction (the same applies to a capsulectomy with a hook), it is wise to grasp that portion which lies out of the eye with a second pair of forceps in the opposite hand, obtaining thereby a new or fresh hold near to the limbus, in this way the stretching of the capsule is minimized, and it may be possible to forestall tearing of that portion which still lies intra-ocularly.

Panas and Landolt devised forceps which have one blade sharp-pointed Their action is that of the de Wecker scissors. The forceps are introduced on their flat and with their blades closed. As soon as the tips of the forceps are well within the anterior chamber, the blades are opened slightly and the capsule membrane is perforated with this blade. They are then closed, and by means of this firm grasp, the capsule may be removed in its entirety (Fig. 456, *C*).

In attempting a capsulectomy there is always the possibility of the capsule tearing. If a large central portion has been removed it is wise to stop further manipulations, in that a capsulotomy has been achieved. If the tear, however, is ragged or incomplete, smooth forceps should be reintroduced, a fresh hold secured and further attempts made until a satisfactory capsulotomy has been achieved. It is most important that no tags of capsule remain incarcerated in the lips of the corneal incision.

Synechiæ which cannot be released were one of the contraindications mentioned. If these are multiple or dense, the traumatism of a capsulectomy may precipitate an iridocyclitis or a cyclitis. Prolapse of the vitreous may occur when it is necessary to reintroduce forceps. If it presents, it must be cut off at the end of the operation, and it may be wise to do a small iridectomy for satisfactory replacement of the iris sphincter. The post-operative treatment is that of atropinization and of hot compresses.

A filtering cystoid cicatrix is occasionally seen following capsulotomy extractions. Careful scrutiny of the case with a slit lamp will usually show a minimal incarceration of the iris. It is also seen at the mid-point of the incision line lying over the mid-point of the coloboma. In these instances, healing occurred with the lips of the sclera slightly offset one from the

other so that a Lagrange type of sclerectomy was the final result. The patient must continue with the usual régime outlined for him if he had been operated for a filtering cicatrix. These cases are susceptible to late infections and must be guarded against them.

Complications in diabetics are minimized decidedly by satisfactory postoperative standardization. These patients are more susceptible to minor traumatisms, for the sclerotic condition of their peripheral circulation permits anterior chamber hæmorrhages more than with the normal; also patients who must be kept under high insulin dosage seem even more susceptible to these. Patients who need considerable insulin to maintain standardization are probably serious cases of diabetes and have difficulty in maintaining satisfactory standardization.

Retinal separation occurs late after cataract extraction in those instances wherein the postoperative convalescence has either been stormy or has been accompanied by one or more of the various complications recently detailed. Linear extractions, the repeated discissions of congenital cataracts, and knife needle discissions are probably the cause of the vitreous changes which antedate or ultimately result in separation. It may be discovered after a cataract operation (even one which has had a most uneventful course), but from its history and appearance it may have existed prior to the lens extraction. Undiagnosed retinal separations, or when unsuccessfully operated, terminate in a cataracta complicata. The interrelationship of these two, therefore, should be kept well in mind to save embarrassment to the operator and to restrain him from surgery which will fail to give any improvement in vision.

Postoperative Glaucoma.—The treatment of postoperative or secondary glaucoma has been covered wholly in the surgical treatment for secondary glaucoma. Certain factors may be repeated here for emphasis. Differentiation is necessary to decide whether the ocular hypertension present is primary, or whether it is secondary and consequent to the lens extraction. Certainly, low degrees of simple primary non-inflammatory glaucoma may pass undiagnosed and go through an uneventful lens extraction. These cases when examined preoperatively may have been in a period of normal tension. Cases which are definitely secondary in origin have usually been complicated during the surgery or during the postoperative recovery. The other alternative is probably true. Cases considered as secondary because they were operated with a capsulotomy extraction, may be actually primary in origin.

Simple primary non-inflammatory glaucoma is handled similarly, whether it appears before or after a cataract extraction. An iridectomy is equally valueless, and a sclerectomy does not lend itself well to these cases. Cyclodialysis should give almost universal success, especially in the cases with the lower degrees of ocular hypertension. Corneo-scleral trephining is the operation of choice, especially if the case has been operated with an intact sphincter. An iris incarceration may be done at one of the pillars of the coloboma in cases with an iridectomy. Many operators trephine these cases, almost routinely, in an inferior quadrant between the horizontal and vertical meridians. Equally good results are reported when the surgery is done in the superior quadrant between the horizontal and the vertical meridian. As long as the trephine opening lies properly on the limbus and not in the line of the healed corneo-scleral section, a peripheral iridotomy

is sufficient for these cases. It is not necessary to do a complete iridectomy. These trephinings may be accompanied by a rather marked degree of striped keratitis which is slow in disappearing. Dionin and hot compresses possibly assist in removing this.

Secondary glaucoma which has its origin in post-cataract extraction can be operated satisfactorily only with corneo-scleral trephining. The inflammatory reaction in some of these is quite a distressing factor and rather difficult to combat. Surgery during such an inflammatory stage is difficult; in fact, practically impossible, and it is not satisfactory. It is necessary, therefore, to attempt to reduce this inflammatory phase. Rest in bed, sedatives, dehydration, amino-glaucosan and atropin with paracentesis of the anterior chamber will be necessary and indicated in the cases which present an accompanying Descemitis. The grossly complicated cases which appear, though fortunately uncommon, of a spreading corneo-scleral incision line, late iris prolapse and iris incarceration, late adhesions to retained cortex and capsule, and those following frank postoperative iridocyclitis, are difficult to handle, and the results are usually not satisfactory (see Corneal Limbal Staphyloma, Chapter XVI).

Corneo-scleral trephining must be done as soon as the inflammatory phase has receded. Until that time it may be necessary to use mydriatics or miotics, or even both, alternating one with the other to keep the tension at the lowest level possible. These cases when operated should have a complete iridectomy. Fuchs' transfixion of the iris with a Graefe knife may assist in reducing the tension of those cases with a secluded pupil, so that trephining may be done later, and an iridocapsulotomy finally.

There are two other forms of glaucoma connected with cataract extraction which should be mentioned here; the one is that which is seen after the loss of some fluid vitreous. The surgery may be quite uneventful and the healing above reproach. Still, in these instances, there is a low-grade sign of chronic inflammatory glaucoma. The use of miotics is usually sufficient to restore normal tension and to hold it thereafter with great satisfaction. The other of the two rare forms of glaucoma is not as satisfactory in this respect. Meller speaks of it as "not benefited by treatment, which follow the growth of epithelium through the wound into the anterior chamber. Clinically, epithelial lining of the anterior chamber is only recognized when a membrane covers a part of the corneo and there is a reflection of a cyst-like formation upon the anterior surface of the iris. Should there be a uniform epithelial lining of the anterior chamber, it can only be suspected but not positively diagnosed." Vail[1] feels that irradiation, either with roentgenology or with radium, offers a little chance of arresting at least the spread of these epithelial downgrowths after cataract extraction.

Various forms of keratitis may occur following a cataract extraction. Some of them are only of academic interest, but others are considerably more important. A classification outlined by Wright[2] considers seven different types.

(1) Striped keratitis which radiates from the edges of the section and is due to a slipping of Descemet's membrane at the time the section is made. This may proceed to an actual detachment of Descemet's membrane as evidenced by a d deep haze radiating from the corneal lip of the section. (2) An adhesive kerat

[1] Arch Ophth., vol. 15, No 2, February, 1936.
[2] Am. Jour. Ophth., Ser. 3, vol 20, No 3, March, 1937.

due to the presence of an anterior synechia from the edge of a buttonhole iridotomy or from the stump of an ordinary iridectomy, or one of the pillars of the coloboma of the iridectomy. (3) A rather similar type of keratitis can occur from adhesions of the capsule far out in the angle of the wound. This may appear in these instances where long shreds of remaining capsule tend to float up toward the incision line. (4) Vitreous adhesions, whether in the presence of large mushroom herniations or because of delayed formation of the anterior chamber, or threads of normal vitreous which have followed the delivery of the lens, may cause a diffused haze of the cornea which can remain permanently (5) A shallow anterior chamber with its endothelium in contact with the iris may also result in a permanent opacity of the cornea. This can be combated in part by touching the lips of the wound with silver nitrate, by the use of miotics, correcting orbicularis spasm or entropion by means of a canthotomy, and guarding against traumatisms as coughing and sneezing. (6) It seems that a very enthusiastic irrigation of the anterior chamber, especially when an irritating or non-isotonic fluid has been used, results in injuring the endothelium (7) Horizontal linear markings appear in the cornea for a more or less temporary period, due there to a folding or bending of the corneal section during the extracting, especially when the section has been too small. In such instances, the line or the furrow will run from the point of puncture to the point of counterpuncture almost bisecting the opening of the palpebral slit.

Fig 457.—Epithelial activity.

Epithelial proliferation is a complication which occurs latest of all, following a capsulotomy lens extraction. Many men have reported a dust-like opacification of the vitreous and a condensation of the hyaloid with a definite depression of vision occurring late after some of their intra-capsular extractions. This is not a matter of epithelial proliferation; it is rather likely the sign of a low-grade iridocyclitis responsible, perhaps, for the cataract changes for which the patient was operated, or may even be connected with trauma to the iris and especially the ciliary body during the intra-capsular lens extraction. There is no surgery which can assist it in these instances, and medication is quite as fruitless. Epithelial proliferation itself results from retention of the equatorial lens epithelium cells, following a capsulotomy extraction. This appears, extending into the pupillary space, frequently following bands of retained cortex and capsule as grape-like clusters of foam or bubbles of varying sizes, all round and evidently cystic in character. Figure 457 illustrates such an instance Surgically they are most difficult to handle. Their texture is so filmy that discission of the mass is of no value, and an attempted capsulectomy simply

results in tearing these masses without removing any appreciable portion of them. If it is possible to dilate the pupil *ad maximum* and to extract the capsule behind the iris from which they arise, then the results will be much more satisfactory. Here, however, the operator is warned against undue tension upon the ciliary body. It is probably best to use a keratome incision and to cut these free from their base with de Wecker scissors and to irrigate them thereafter from the anterior chamber.

Wright,[1] in discussing postoperative complications of cataract extraction, talked about various conditions which are to be avoided. Some of these, as he considered them, follow:

(1) Constipation and straining at the stool must be anticipated and avoided. If necessary, it is much better to get the patient up on a stool rather than have him do damage to his eye through the uncomfortable use of a bed-pan, and some patients do protest the use of a bed-pan Hæmorrhoids are an undesirable complication and require special nursing. (2) Difficulty in emptying the bladder is not uncommon the first twelve hours. A distended bladder should be prevented and, if ordinary methods fail, as permitting elevation with a back rest, and hot stupes over the lower abdomen, then catheterization is indicated. In patients with prostatic enlargement the catheterization should be done carefully to prevent pain and squeezing of the lids therefrom. (3) As coughing is sometimes the cause of expulsive subretinal hæmorrhage, of emptying the anterior chamber, of some cases of anterior chamber hæmorrhage, of iris prolapse, and of gaping of the wound, it must be considered. Full dosage of cough sedatives should be used until the section is firm. Cocain and chloretone instillation into the eyes may prevent sneezing. One must be careful in the medication at the time of his dressings that nothing is used that will cause the individual to sneeze. For this reason dionin, when used after an operation, should be started with a weak solution. (4) Irritable conjunctivæ and lids are seen occasionally in patients susceptible to eczema Drug irritations occur in such cases, with both atropine and eserin. (5) Postoperative vomiting, quite apart from morphia, may occur from unknown reasons To prevent this and to control it, if it has occurred, attention should be paid to the diet. Small pieces of chipped ice, iced ginger ale, and iced champagne will settle the stomach at times. A mustard plaster to the epigastrium has been used. Drops of essence of peppermint upon a lump of sugar, and cocain applied to the oral pharynx have several times proven of value.

Wright further pays attention to the position in bed, so that it will be one of comfort. A rigid attitude with regard to posture must be avoided For crippled and arthritic patients, as also in cardiac and pulmonary cases, special arrangements must be made to insure suitable postures and good nursing. Surgical beds have the great advantage of providing for semi-recumbent and sitting positions. But an easy chair at the bedside may be used with great comfort and benefit, sometimes the day after operation. Latitude of movement, however important, must be tempered with due warnings against abrupt, jerky, or jarring motions Wrist bandages to limit movements may often be valuable for inquisitive and irresponsible patients. Some of these matters may seem trivial but they claim our attention sufficiently often to make us exercise serious care in dealing with them.

[1] Am Jour Ophth, Ser 3, vol 20, No 3, March, 1937

CHAPTER XXI

SURGICAL INDICATIONS IN THE GLAUCOMAS

The various types of primary and secondary glaucoma, as they are usually grouped, have varied symptoms, individual pathological changes, and demand different surgical procedures for their correction. The differentiation of primary and secondary is, at the best, unsatisfactory, but for the present it must suffice.

THE DIAGNOSIS AND SURGICAL INDICATIONS FOR SIMPLE NON-INFLAMMATORY GLAUCOMA

A diagnosis of simple non-inflammatory glaucoma means early surgical intervention. There can be no exception to this unless in those cases where the patient's condition, by reason of age, or other concurrent and coincident illnesses, makes it impossible to operate. Such conditions do arise and must be handled individually with the best judgment possible. For instance, simple non-inflammatory glaucoma with myocardial disease, with hypertension and accompanying coronary pathology, simple non-inflammatory glaucoma in the insane, and simple non-inflammatory glaucoma with diabetes are examples of these cases. A case of concurrent cardio-vascular pathology can be operated at times through the coöperation of a capable cardiologist. Preoperative sedation is a most valuable adjunct. Diabetics must be standardized before surgery. In some instances the condition of the fields of vision, especially careful studies of the central fields and of the angioscotomata leading from the blind spot, can be utilized as the criterion for the amount of delay permissible.

Gradle and Sugar[1] recently discussed the value of anterior chamber angle examination and measurements to determine, if possible, any relationship which may be present between the acuity of the angle of the anterior chamber to the depth of the anterior chamber, and these, in turn, to studying and evaluating preglaucomatous eyes. The procedure should be of *assistance in deciding what cases need immediate surgery, and may indicate* such apparently normal eyes which should be watched for further evidences of impending glaucoma. The depth of the anterior chamber according to their technique was measured in millimeters by the use of an Ulbrich drum, mounted upon a Zeiss slit lamp microscope, using as their point of measurement the margin of the pigment border of the 3 mm. pupil for the cornea as well as the iris. The chamber angle depth was then measured by a new gonioscopic method, utilizing the Koeppe gonioscopic contact glass and a micrometer graticule etched in tenths of a millimeter in one of ×5.5 microscope oculars. Their procedure, which they term "Goniometry," showed that the acuity of the angle of the anterior chamber bore a gross but inconstant relationship to the depth of the anterior chamber, and was of greater value from the clinical standpoint than the depth of the anterior chamber alone.

[1] Am. Jour. Ophth., Ser. 3, 23, No. 10, 1135, October, 1940.

Kronfeld[1] in speaking of the practical value of gonioscopy, as abstracted in the *Digest of Ophthalmology and Otolaryngology*[2] states:

The gonioscopic findings in cases of primary glaucoma may be grouped under three headings: (1) The spatial relationship between the ciliary portion of the iris and the lateral wall of the angle. (2) Abnormal tissue elements in the angle (3) Topographic changes in the angle resulting from antiglaucomatous operations.

The normal spatial relationship between iris and lateral wall of the angle is characteristically altered in so-called primary glaucoma. After glaucoma has been present for a certain time, portions of the iris lying opposite the corneoscleral trabeculum form adhesions with the latter—the glaucomatous peripheral anterior synechia. This formation of adhesions usually starts in the upper portion of the angle, involving first the most peripheral portion of the trabeculum. From there the adhesion spreads in meridional as well as in circumferential direction until the entire corneo-scleral trabeculum over the entire circumference is covered by iris. The original chamber angle thereby becomes obliterated and a new angle is formed, the apex of which lies approximately at the posterior end of Descemet's membrane

The time in the evolution of glaucoma at which the formation of the synechiæ begins varies in the different forms of glaucoma. In simple chronic glaucoma the anterior synechiæ form, as it were, during the last act of the drama, whereas in the congestive incompensated variety of glaucoma the anterior adhesions develop relatively early. In the extreme form of incompensation, the acute attack, the entire circumference of the trabeculum may become firmly covered by iris within the first twenty-four hours of the attack. For most forms of primary glaucoma it holds true that the glaucoma is definitely established before permanent synechiæ form. While the latter cannot be considered the primary cause of most forms of glaucoma, the development of the synechiæ probably aggravates the insufficiency of the pressure-regulating apparatus of the eye.

In the cases of primary glaucoma, in which the anterior chamber is moderately deep or only slightly shallow, the appearance of the chamber angle during the presynechial stage does not differ from that of the non-glaucomatous eye except for the presence of pigment in the trabeculum This fact has led O Barkan to revive the old theory that pigment infiltration of the trabeculum was the cause of primary glaucoma.

A different situation prevails with regard to glaucoma with shallow chamber There, gonioscopy reveals narrowing of the entrance to the chamber angle, that is, the space between root of the iris and the corneo-scleral junction In these cases gonioscopy also shows that crowding to the periphery of the iris, as it occurs under the influence of mydriatics or during emotional upsets, may close the entrance to the chamber angle and thereby lead to a sudden acute embarrassment of the intraocular fluid circulation. In the more marked degrees of shallowness of the chamber, the more peripheral (posterior) portions of the lateral angle wall and the angle itself may be hidden from view by the bulge of the iris The portion of the lateral wall that is visible gonioscopically may thus serve as a measure of the forward-displacement of the iris or the shallowing of the chamber. In cases of shallow chamber without signs of glaucoma, gonioscopy is of practical value inasmuch as it enables one to recognize those cases in which dilation of the pupil may close the entrance to the chamber angle. On the other hand, studies of this kind reveal that in eyes with a generally shallow chamber, the entrance to the angle may be of such width that even marked dilation of the pupil does not interfere with the flow of fluid toward the chamber angle.

One important lesson that gonioscopy has taught us is that absence of the anterior chamber for several days invariably entails the formation of peripheral anterior synechiæ which are not essentially different from those adhesions that develop spontaneously in primary glaucoma Such synechiæ may develop in any case of intra-ocular surgery after which the anterior chamber remains collapsed for several days. Their extent in meridional direction appears to be dependent upon the duration of absence of the anterior chamber. Since after the trephine operation the chamber tends to be abolished for longer periods than after iris

[1] Wisconsin Med Jour., August, 1941.
[2] Digest Ophth. and Otolaryn , December, 1941.

inclusion operation without sclerectomy, the postoperative synechiæ are most marked after trephine operation.

This finding is open to different interpretations. Some ophthalmologists reason that the existence of a glaucoma in the presence of an open angle before the operation proves the ineffectiveness of the angle as an outlet for intra-ocular fluid and therefore the loss of this angle is of no significance. As long as the trephine opening acts as a safety valve it is true that the loss of the function of the original chamber angle is not noticeable. If, however, no permanent drainage through the trephine opening is established, the postoperative synechiæ definitely add to the insufficiency of the pressure-regulating apparatus of the eye that existed before the operation and the glaucoma is usually rendered more severe, as far as one can judge from the behavior of the intra-ocular tension under the same amount of miotics as before the operation. There are ophthalmologists who endeavor to avoid these postoperative adhesions by restoring the anterior chamber at the end of the operation by injecting saline or air into it. How effective these measures are in preventing postoperative synechiæ is not definitely known at this time.

A serious embarrassment of the fluid-exchange of the eye is caused by synechiæ if they develop after cataract extractions. Ordinarily there is no permanent drainage established through the operative incision, so that the eye depends on its natural fluid outlets, of which the chamber angle is doubtless the most important one. Extensive peripheral anterior synechiæ after cataract extraction are invariably associated with secondary glaucoma.

These postoperative adhesions are one example of the value of gonioscopy for the evaluation of operative results. Another example is the cleft between sclera and ciliary body produced by a cyclodialysis. This cleft can easily be seen gonioscopically, the magnification provided by any binocular loupe being sufficient for its recognition. If, after a cyclodialysis, such a cleft is plainly visible, the prognosis is very good, because in patients with such a cleft the tension usually remains below 18 mm. of mercury without the use of miotics. If no supraciliary cleft can be seen gonioscopically after a cyclodialysis the operation practically always proves to be a failure in the sense that the course of the glaucoma is not appreciably altered.

In simple non-inflammatory glaucoma, as in any form of surgery for glaucoma, there are three possible means of correcting the mechanics at fault. The first is that which has, as its purpose, a reopening or reëstablishment of the usual channels for drainage, that is, the anterior chamber angle and Schlemm's canal. Iridectomies and sclerotomies typify the surgery for this purpose. The second is done with the hope of reëstablishing new intra-ocular channels for drainage (Gradle) and at the same time to lessen the formation of the aqueous by throwing out of function a portion of the ciliary body and the nerve supply to the ciliary body. Cyclodialysis is the method for doing this. Cyclodialysis clinically is a sound surgical procedure and is quite successful in properly selected cases. Heine stated[1] that "cyclodialysis is especially indicated in those cases where the surgery is not an urgent necessity. It may be imperative but it is not an emergency." Gradle's statement as he quotes Heine[2] is as follows:

> I believe that the original Heine dictum still holds true. The more urgent the indications for operation in glaucoma, the less beneficial are the results from cyclodialysis, and the less urgent the indications for operation, the better are the results from cyclodialysis.

Unfortunately, the operation is too often considered not as one to be initially chosen, because of definite indications, but as "the court of last appeal." In such instances, earlier surgical procedures having failed, a

[1] Die Cyklodialyse eine neue Glaukomoperation, Deutsch. med. Wchnschr., No. 21, p. 824, 1905 (translation).

[2] Discussion on the Late Operative Results in Glaucoma, Edmund B. Spaeth, Trans. Am. Acad. Ophth. and Otolaryng., p. 194, 1928.

frenzied attempt is made to correct the hypertension and the operator "tries a cyclodialysis." The third procedure is the formation of a corneo-scleral (limbal), fistulizing cicatrix, to permit filtration into the subconjunctival tissue as a new and artificial outlet for drainage.

Considering these demands one can see readily why, in at least 50 per cent of cases, a simple broad glaucoma type of iridectomy, spoken of so commonly as a "basal iridectomy," is doomed to failure in simple non-inflammatory compensated glaucoma, and in certain forms of secondary glaucoma. The normal filtration channels are fibrosed and closed and can no longer be opened. The sclerotomy of Barkan apparently offers, according to Barkan's results, a greater percentage for success This is undoubtedly due to the direct visual control of the angle incision made possible by the technique. Cyclodialysis has in simple non-inflammatory glaucoma its outstanding indication. The higher ranges of increased intra-ocular tension need a fistulizing operation. It is not uncommon to find a small remaining paracentral and central field of vision (representative of the last remaining functioning portion of the retina) wiped out completely postoperatively after an iridectomy. Samuels (personal communication) believes that this is due to one of several possibilities:

(*a*) Minute capillary hemorrhages from the chorio-capillaries in the macular region due to the abrupt drop in tension and the inability of the inelastic choriocapillaries to adjust themselves to this change, (*b*) macular detachment caused by subchoroidal transudates and also dependent upon the abrupt pressure changes, (*c*) sectioning of the remaining nerve fibers against the scleral spur and within the cribriform plate by this same process of pressure changes, though we know that the degree of excavation in a glaucoma cup changes but little, if at all, following successful surgery; and (*d*) hemorrhage which has occurred into the optic nerve itself from the central retinal vessels.

Simple non-inflammatory glaucoma, accompanied by lens changes of such a degree that cataract surgery is imminent, should be operated by a fistulizing operation regardless of what may be necessary later. If one is in doubt as to whether the glaucoma is primary or secondary to lens swelling, it is best to consider it of a primary nature and to treat the case accordingly. (See section under Preliminary Iridectomy, page 601.) Every ophthalmologist with an extensive surgical practice has, it is certain, erred in this matter one or more times. In most instances, a subsequent corneo-scleral trephining has prevented further damage, but other cases are not as fortunate. Simple non-inflammatory glaucoma with diabetes has, as its outstanding characteristic, a marked postoperative irregularity, unpredictable and occasionally most distressing.

Glaucoma surgery in the paretic is complicated by the Argyll-Robertson pupil with its fixed or relatively immobile sphincter iridis, and postoperative iritic adhesions develop in them quite readily. A complete iridectomy with corneo-scleral trephining does decrease the incidence of subsequent iritic adhesions, but at the same time other more important factors enter therein.

The best results obtained by corneo-scleral trephining seem to be in cases wherein the smallest possible iridotomy has been done. Iris motility in its response to miotics and mydriatics should be studied in every case. Upon the findings therefrom it may be possible to decide that a complete iridectomy is necessary in a case under consideration, regardless of the disadvantages which may accompany this technique.

THE DIAGNOSIS AND SURGICAL INDICATIONS FOR ACUTE CONGESTIVE GLAUCOMA

Congestive glaucoma is no less a surgical condition than is the simple non-inflammatory form. On the other hand, these cases have a more or less clear-cut, logical, preliminary medical approach. Many men have called attention to this, but all agree that if a subsidence of the attack cannot be obtained within six to twelve hours, it is probable that surgery will be necessary. As Gradle states,[1] approximately 90 per cent of patients with an acute incompensated glaucoma, if they are operated within forty-eight to seventy-two hours after the beginning of the attack, will retain useful vision. The longer the operation is postponed, however, the poorer do the chances become. If a case has been preceded by adequate pre-operative medical attention, and if, after forty-eight hours, there is not a definite decrease in the severity of the symptoms as measured by the ocular tension, the size of the pupil, the depth of the anterior chamber, the condition of the cornea, the degree of pain present, and the visual acuity return—surgery is definitely indicated. The classical Graefe iridectomy is undoubtedly the operation of choice during the acute congestive phase. Other forms of surgery are impossible at this time.

A reduction in the degree of congestion would permit a corneo-scleral trephining. Under such circumstances, one is approaching compensation in the case under question; therefore, as in compensated glaucoma, the corneo-scleral trephining operation, or some similarly fistulizing operation, is the ideal. Posterior sclerotomy has been advised as a preliminary procedure twenty-four to forty-eight hours before the broad iridectomy is to be done (see section on Posterior Sclerotomy under Surgery of the Sclera, page 526). It reduces the congestive phase, lowers the tension temporarily, and not only deepens the anterior chamber but also seems to permit a better absorption of and response to the miotics being used. Posterior sclerotomy, however, is not without danger, and if it is practiced the indications for it should be definitely present. In unilateral congestive glaucoma one must use miotics in the non-involved eye. It is not uncommon for an attack to develop in this occasionally, intercurrently with the surgery to the first eye. For this reason, if there are any ophthalmoscopic or field changes, dark-adaptation disturbances or ocular tension changes in the uninvolved eye, suggestive of glaucoma, this eye also should be operated either by cyclodialysis or by corneo-scleral trephining. Many cases of unilateral acute congestive glaucoma which had been operated by an iridectomy later need the further assistance of corneo-scleral trephining in the same eye. It must be done if there is any tendency to subsequent hypertension. Doryl, a stable parasympathomimetic agent, many times more active than acetylcholine, is quite valuable in holding these cases stable; actually of greater value in this type than in the simple non-inflammatory conditions. Clarke[2] found that the effectiveness of doryl is strongly increased if accompanied by massage of the eyeballs for two minutes after instillation. The cases should not be permitted to continue with miotics indefinitely with the vain hope for a later establishment of a normal intraocular tension.

[1] Berens The Eye and Its Disease, p 707, Philadelphia, W B. Saunders Co., 1936.
[2] Am. Jour Ophth., March, 1942.

The use of mydriatics (atropine and scopolamine) or of miotics (eserin and pilocarpin) following an iridectomy calls for good judgment and for close observation of the case. This statement applies not only to iridectomy but also to iridencleisis, to cyclodialysis, and even more so to trephining. In most iridectomies a mydriatic should be used immediately postoperatively. The anterior chamber is open, and the mydriatic will allay the irritation from the iris insult coincident to the surgery. Any tendency to the formation of synechiæ must be combated. Atropinization is definitely necessary following sclerectomies and trephinings, and in these instances, the mydriatic must be continued until the eye is white. (See section on Complications of Glaucoma Surgery.)

THE DIAGNOSIS AND SURGICAL INDICATIONS FOR CHRONIC CONGESTIVE OR CHRONIC INCOMPENSATED GLAUCOMA

This is rather likely the result of repeated attacks of acute congestive glaucoma or the termination of a single violent attack of the acute congestive inflammatory form. All three may terminate the same; that is, in absolute glaucoma, though even here the simple non-inflammatory variety does not go on to the degree of degeneration which is occasionally seen late following the acute and chronic congestive forms. The surgery of this is not as satisfactory as is that of the two varieties already discussed. Iridectomy is seldom indicated in this form, for the end-results of a simple iridectomy in chronic congestive glaucoma are the least satisfactory Corneo-scleral trephining, the iridosclerectomy of Lagrange, or an iris inclusion operation are especially applicable to this type of case. These cases are essentially surgical, and unless surgery is done, absolute glaucoma will certainly occur. The amount of visual acuity which is recoverable in them also is not as great as is that remarkable degree of recovery seen frequently after recovery from acute congestive attacks. The improvement is directly proportionate to the length of time that the case has been standing, depends upon the amount of permanent damage, which occurs in the nerve head, and can be estimated, in part, by the appearance of the cornea, the condition of the iris, and by the amount of ocular hypertension which has been present.

THE DIAGNOSIS AND SURGICAL INDICATIONS FOR ABSOLUTE GLAUCOMA

Absolute glaucoma, the final stage of all forms of glaucoma, yields little, if at all, to surgical treatment. Enucleation is the indicated operation in such instances. Occasionally, the patient will refuse an enucleation and a corneo-scleral trephining may be tried, but it is not especially successful. Occasionally a conjunctival seton operation, as with Gradle's conjunctival drain technique, offers a higher percentage of successes, but most of these cases are hopeless. If the eye is painful and otherwise annoying, then enucleation becomes imperative.

THE DIAGNOSIS AND SURGICAL INDICATIONS FOR SECONDARY GLAUCOMA

In this consideration and more or less arbitrary subdivision of glaucoma into primary and secondary, one is of necessity strongly influenced by a sentence from Duke-Elder:[1]

[1] Text-Book of Ophthalmology, C. V. Mosby Company, vol. 3, 1940

Ætiologically, pathologically, and clinically, the term glaucoma includes so many disease-entities that it is impossible to consider them as different manifestations of the same condition. In the present state of our ignorance, however, it is useful to admit a classification into two groups—secondary glaucoma, wherein the symptom of raised pressure is due to some obvious ocular lesion, which is known—and primary glaucoma, wherein the raised pressure is due to some inobvious cause at present unknown.

Glaucoma, regardless of whether it is primary or secondary, is caused on the face of things by, as Duke-Elder said, some condition unknown. Hence, upon the ground of cold scientific deduction, all forms of glaucoma are secondary to some neurogenic, anatomic, (mechanical), or even traumatic disturbance There is, however, a differentiating threshold illustrated best by the therapeutics necessary for obtaining best results.

To continue Duke-Elder's quotation, secondary glaucoma

may therefore be defined as a loosely knit and unrelated clinical group of cases, the only common denominator among which is the fact that some recognized pathological lesion is complicated by an increase in the ocular pressure with attendant symptoms

In the discussion on the anatomical causes for secondary glaucoma a statement was made to the effect that the essentials necessary are the correction of or the removal of the underlying cause. While this is true, in general, it is oftentimes difficult in any specific instance. Secondary glaucoma with staphylomata, especially the postoperative limbal staphylomata with a degenerated iris and a lost anterior chamber, is a hopeless case surgically. An enucleation is the only thing which should be done for such cases. Surgery for acute iritic glaucoma should not be of an emergency type, even though the condition is alarmingly inflammatory. In general, the greater the iritic inflammation and the amount of descemetitis present, the less imperative are the surgical indications This includes all possible surgical procedures except that of corneal or anterior chamber paracentesis. As the acute inflammatory symptoms recede, then surgery may be considered more seriously The statement is not paradoxical, for the inflammatory phase of these conditions will recede from an iritic and iridocyclitic standpoint without a proportionate abatement of the hypertension. These cases can clear up wholly from the inflammatory standpoint and swing over into an occlusio et seclusio pupilla, with an iris bombé, for this type of secondary glaucoma may present the signs and symptoms of a relatively low grade chronic inflammatory process.

Larsen[1] studied the histories of 50 cases of iritic glaucomas. In those cases treated with mydriatics the results were far better than in those treated with miotics. In 38 cases, atropin was used and never caused an acute exacerbation; while in several cases, miotics when used caused an acute rise of pressure. In only 2 of 19 cases of iridectomy were the results perfectly satisfactory; and after trephining, the results were even worse than with iridectomy, but trephinings were performed frequently in cases where the pressure did not become normal after iridectomy. Operation must be performed in those cases wherein a rise of pressure cannot be combated by more vigorous treatment. It is important to remember that every case of iritic glaucoma is an inflammatory case and must be treated as such, and not as one of primary glaucoma.

[1] Arch f Ophth (Graefe), Berlin, 115, 144, 1924.

Granted the presence of surgical indications in a case of iritic or secondary glaucoma, an iridectomy, if it is possible, is the most logical procedure. Iridencleisis and iridotasis do not lend themselves to the problem The subconjunctival incarceration of an acutely inflamed, chronically inflamed, and vascular iris, or of a degenerated iris does not result in a satisfactory filtering bleb. The same thing applies to cyclodialysis. The rationale of a cyclodialysis operation may not depend wholly upon the opening of the subchoroidal space and subsequent filtration; but even so, an irritated and inflamed ciliary body (as present with an iritic glaucoma) cannot respond to a cyclodialysis operation. If a corneo-scleral trephining could be done in the case, considering the degree of inflammation present, the final results might be better, but here also, as Samuels has shown, exudation mats the contiguous ciliary processes into a plug, closing completely the trephining opening. Trephining cannot be done during the acute inflammatory phase of any type of case, nor is it satisfactory in cases with a history of former inflammation. The presence of a coëxisting descemetitis is likely evidence of such an inflammatory relationship.

Secondary glaucoma following cataract surgery and as a complication of cataract surgery needs further surgical intervention for its correction. If the lens was extracted with an iridectomy, a corneo-scleral trephining opening may be done externally to the lateral pillar, or nasally to the median pillar. It may also be done below at 6 o'clock, so that the bleb is covered by the lower lid if the iris there is in the best condition. Cyclodialysis lends itself well to these instances if the cases are not inflammatory in type. Trephining, in the presence of aphakia, may be nullified by vitreous plugs, by subsequent traction on the ciliary body, or by a closure of the trephine opening by antroflexed ciliary processes. Cyclodialysis, on the other hand, is not modified in any way by the aphakia. An early diagnosis is necessary if vision is to be saved. Ralston and Goar[1] feel that a fistulizing operation is necessary, for they believe that the glaucoma results from vitreous blocking the spaces of Fontana.

Secondary glaucoma, from large corneal wounds with massive iris prolapse usually passes over slowly, but definitely, into an atrophy of the eyeball. The complicating traumatic cataract, which is occasionally present, does not seem to effect the course of the glaucoma, even if the cataract is removed. Meller recommends a broad iridectomy in or at a normal position on the limbus as an essential and immediate procedure as soon as the secondary hypertension first appears.

Glaucoma capsulo-cuticulare, the glaucoma of high myopia, and glaucoma with nævus flammeus respond poorly to all surgery; it is likely that fistulizing operations will give the best results. In these conditions, prostigmine, acetylcholine preparations and doryl should be first tried before surgery is used, and continued after the surgery.

Secondary hypertension caused by an old iritis, with total adhesions of the pupillary surface to the lens, develops first, not from the retention of the aqueous humor in the posterior chamber, but because the root of the iris is forced against the angle of the anterior chamber, obliterating it; and second, according to Terson,[2] the vitreous body and the retina must be in good condition to constitute a solid back. In these cases a basal iridectomy

[1] South Med. Jour., 15, 581, 1932.
[2] Ann. d'ocul Paris, 85, 441, 1922.

is indicated, without argument or controversy. It is one of the outstanding single indications for iridectomy or even iridotomy. This is especially true in old syphilitic serous iridocyclitis, and in iridocyclitis associated with tuberculosis. Terson enters the anterior chamber at a variable point, corresponding to the greatest elevation of the iris from the lens. He incises the iris with the point and the cutting edge, allowing the subiritic stream to escape as the knife is withdrawn without injury to the lens. Wherever iridectomy is impracticable or dangerous he performs this, as he calls it, "kerato-iridic paracentesis."

Transfixion of the iris (the Fuchs' four-point iridotomy), sphincterotomy, and sphincterolysis, have been discussed under iris surgery, page 587. The de Wecker iridotomy and iridocapsulotomy are considered under the late complications of cataract surgery, Chapter XX. They all are indicated occasionally in the surgical treatment of secondary glaucoma, though they have as their basic reason the opening of the pupillary aperture.

The surgery of secondary glaucoma with essential atrophy of the iris has been quite unsatisfactory. Corneo-scleral trephinings should help, if anything can, but these rather rare cases almost always end in a phthisical eye, in hypotension with a complete separation of the retina, and with band-shaped keratitis. Enucleation ultimately is essential.

The secondary glaucoma of a dislocated lens is not always a simple problem A lens traumatically dislocated into the vitreous frequently can be localized ophthalmoscopically and successfully fished from the vitreous with a lens loop. The vitreous lost, however, is often considerable and may cause phthisis bulbi. The acute secondary glaucoma of abrupt and recent posterior dislocations of the lens gives apparently somewhat better results In some of these cases the lens extraction is followed by a fatal (to the eye) subchoroidal hæmorrhage, for these cases appear most frequently in the aged who have an already weakened zonula.

Dislocation of the lens into the anterior chamber should be held therein by eserin contraction of the iris behind the lens and the very early extraction of the lens While the indications for the surgery are very plain in these cases the secondary glaucoma which develops is always severe.

The secondary glaucoma of traumatic cataract is usually relieved as soon as the lens masses have been washed from the eye, either through keratome *incision and lavage or by a more extensive linear extraction. A similar* situation is seen occasionally before the linear extraction, after a lens discission. Not infrequently, a descemetitis may be an additional complication. Repeated anterior chamber paracenteses will be necessary—lens protein disensitization will be of assistance at times, as well as foreign proteid therapy. When these cases are further complicated by a plastic iritis, with occlusio et seclusio pupillæ, then the case is in a rather serious condition prognostically, as to ultimate visual acuity.

Acute hæmorrhagic glaucoma usually demands immediate posterior sclerotomy if the eye is to be saved with any remaining vision. Several instances appear in the literature of very satisfactory results in the treatment of hæmorrhagic glaucoma with roentgen-ray therapy. Brunetti[1] reported 4 cases of hæmorrhagic glaucoma treated by roentgen-ray with two and three periods of irradiation, over an interval of three weeks. Pain began to disappear after the second irradiation, and at the end of the treat-

[1] Actinoterapia, Naples, 3, 70, 1923.

ment it had disappeared wholly, and the hypertension was steadily falling. The procedure may be applicable in certain inoperable cases.

In secondary glaucoma from epithelial down-growths into the anterior chamber following cataract extraction according to Vail[1] one may offer some hope of arresting at least the spread of the process. The chief point to be settled, according to Vail, is whether the roentgen-ray or radium is the better agent.

It appears from the study of the few cases reported that the roentgen-rays are more effective. The second point is the determination of the proper dosage and the method of application It must not be forgotten that epithelialization of the anterior chamber is a destructive lesion and calls for drastic treatment regardless of its dangers to the eye.

The available evidence seems to indicate that the newly formed epithelial cells are destroyed readily by the roentgen-rays and that these are not harmful to normal ocular structures if properly applied The writer must agree with Vail that once the glaucoma is established surgery is fruitless, and an enucleation will terminate the case. If the cyst can be removed, *in toto*, early in its course by means of an iridectomy, some hope can be held out for an ultimate cure. (See Epithelial Ingrowth in section on Complication of Corneo-scleral Trephining.)

Corrado[2] pointed out that it was not sufficient for a strip of epithelial tissue to happen to fall into the anterior chamber in order to have attachment and proliferation occur. He showed that only when the corneal wound remains open beyond a certain time is it possible for the corneal epithelium, by proliferation, to penetrate into the anterior chamber after having covered the border of the wound itself.

The secondary glaucoma which develops in a case of post-thyroidectomy exophthalmos, due undoubtedly to vortex vein bulbar venous stasis (because of the orbital edema, etc.) will not respond to either surgery or to miotics until the orbital edema has been relieved by some type of orbital decompression. Thereafter, the miotics are usually adequate.

THE DIAGNOSIS AND SURGICAL INDICATIONS OF BUPHTHALMOS

Keratoconus, keratoglobus, anterior staphylomata, corneal staphylomata and megalocornea must not be confused with buphthalmos or hydrophthalmos. In considering buphthalmos and juvenile glaucoma, Snell[3] makes a great point in differentiating buphthalmos from juvenile glaucoma by the history of the case and certain signs and symptoms present. According to him, that which he speaks of as juvenile glaucoma has its onset developing earlier than senile glaucoma. Heredity is a direct etiological factor, transmission being from generation to generation without intermission; it often occurs in several members of the same family. Smallness of the cornea has been noted in many cases, and where measurements have been made the horizontal diameter has been found to be less than 12 mm. Lohlein found that 50 per cent of his cases were myopic and 50 per cent had other congenital anomalies. A differential diagnosis between infantile (buphthalmos) and juvenile glaucoma depends on certain differences. In the infantile

[1] Arch Ophth, vol 15, No 2, February, 1936
[2] Ann. di Ottol de clin ocul, 59, 706, 1931
[3] New York State Jour Med, 23, 151, 1923.

type, the onset is in the first decade, direct inheritance is rare, and it does not occur in succeeding generations. The horizontal diameter of the cornea is over 12 mm., often 25 to 40 mm. The anterior chamber is deep. The

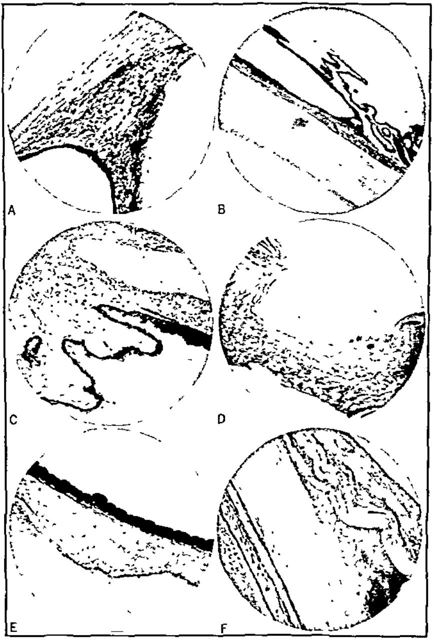


FIG. 458.—Microphotographs of anterior chamber angles of *A*, buphthalmos, *B*, absolute glaucoma *C* and *D*, recurrent chronic inflammatory glaucoma, angle and disc; *E*, angle of secondary glaucoma with staphyloma, and *F*, with acute hæmorrhagic glaucoma.

condition is chronic, and the eye predominantly is blue. The juvenile type has its onset at ages ranging from ten to forty years. It is always a direct inheritance, and occurs in successive generations. The horizontal diameter of the cornea is under 13 mm. The anterior chamber is usually shallow.

The condition may be either acute or chronic, and the color of the scleræ is normal. Hardesty,[1] from his experiences, feels that it is wise to consider the possibility of thymus hyperactivity in cases of infantile glaucoma.

Experience with operations in these cases shows that iridectomy is of little value, for there is an anatomical defect in the filtration angle, but there is some promise of permanently reducing tension by some form of filtrating cicatrix. Snell believes that the Elliot operation is the operation of choice. Corneo-scleral trephinings have in some instances held the eyes in normal tension for many years; in other cases the operation has been followed by a rather rapid collapse of the eye and rather progressive degeneration to

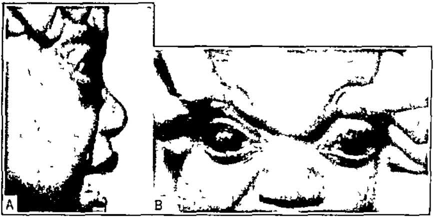


FIG 459 —Buphthalmos, bilateral

phthisis bulbi. Repeated cyclodialyses have been successful in some instances; they can be repeated as necessary, and, further, the pathological anatomy present and the surgical principles of the operation are not at variance. The anatomical defect of congenital iris angle adhesions, which presumably stretch and tear in later years with the growth of the eyeball is perhaps responsible for some of the recoveries reported, and the cause, probably, of the not uncommon hypotension seen ultimately, though now in a blind eye. Figure 458 illustrates certain definite findings connected with this all important factor, the microscopic changes, so conclusively that further text is unnecessary. Figure 459 is the side and front views of a classical case of buphthalmos.

[1] Am Jour Ophth, Ser 3, vol 17, No 8, 1934

CHAPTER XXII

THE SURGERY OF GLAUCOMA IN SPECIFIC INSTANCES. THE SURGERY OF GLAUCOMA AS IT APPLIES TO THE IRIS

OPERATIONS FOR OCULAR HYPERTENSION

Individual Indications.—The various forms of glaucoma have just been discussed (see previous chapter) from the standpoint of the problems present, in the various types of cases, and the surgery at our command which best meets these demands. This section, as applied to glaucoma, is from the standpoint of these surgical procedures applied to the various types individually. Of necessity, the questions connected with these can be answered only after a study of late results in the operative treatment for glaucoma.

The author, in 1928,[1] in A Consideration of the Late Operative Results in Glaucoma, analyzed a series of 225 cases of all types of glaucoma operations as they appeared at least five years after the surgery. Since the writing of that paper many new experiences and several larger series have been presented in the literature from time to time. It is remarkable how few are the changes which have appeared. Of the numerous operative procedures practiced for this condition, some have merit and are based upon sound surgical principles; others have been presented, however, manifestly lacking in efficiency, largely because the surgical principles involved were basically unsound. There is no doubt that in glaucoma surgery the choice of the operation is influenced by the individual operator's ability to acquire the technique required for the correct performance of that operation. This is the first demand; the second is that the operation of choice be one which, in the opinion of those of largest experience, has yielded the best results. Multiplicity of methods is not necessarily indicative of unsatisfactory results; it is just as likely an indication of pleomorphic demands. If so, no operator can limit himself to any one operation to the exclusion of others. They all may have a place in the armamentarium needed for treating this condition. All other things being equal, the operator should follow the practice of John E. Weeks, who said: "Whatever method the operator can use with confidence is the best method for him." Undoubtedly, several methods are available for operating chronic glaucoma and obtaining a satisfactory result. Therefore, that which the operator can do best should be done in any one case, if it is applicable to the type of case under consideration.

Emil V. de Grósz[2] presented an analysis of glaucoma operations extending over thirty years of practice at the First University Eye Clinic of Budapest, illustrating that which was just said relative to the opinion "of men with large experience." In thirty years he treated 4326 patients with 6043 glaucomatous eyes of, or with, primary glaucoma. Of these cases, 5062 operations were done for primary glaucoma. They included 2773

[1] Trans. Am. Acad. Ophth. and Otolaryng., 1928.
[2] Wien. med Wchnschr., 85, 312, 1935.

iridectomies, 755 Elliot corneo-scleral trephinings, 168 Lagrange sclerectomies, and 1006 cyclodialyses. In this series only 10 iridencleisis were performed. Two hundred and fifteen sclerotomies were also done. Further notes relative to this series will appear under the specific operations.

Barkan,[1] in discussing a choice for glaucoma surgery, has considered the surgery unnecessary and underrated on the basis of anterior chambers angle charges. His opinion, abstracted from the Digest of Ophthalmology and Oto-laryngology[2] follows herewith; also his condensed chart in summary.

Examination of the chamber angle (gonioscopy with the binocular microscope) makes it possible to follow the development of glaucoma throughout its course from the earliest to the latest stage and to classify glaucoma on a pathogenic basis into types and stages corresponding to factual conditions.

Glaucoma may be divided into two great types, characterized principally by the location and nature of the obstruction causing retention of intra-ocular fluid: (1) Trabecular glaucoma: The reduction in outflow is located in the trabeculum. The reduction may be due either to mechanical obstruction or to the physicochemical composition of the aqueous. The angle is wide or open (chamber depth normal or deep). In this form of glaucoma iridectomy is of no avail. Trabecular glaucoma usually runs a non-congestive compensated course.

It sometimes develops signs of congestion and decompensation. When these signs occur, the case is apt to be erroneously diagnosed as one of "chronic congestive glaucoma," and surgical interference is by means of iridectomy. As stated above, this is without effect in trabecular glaucoma. (2) Narrow-angle or iris-block glaucoma: The obstruction to outflow is due to closure of the angle by the iris root lying in apposition to the angle wall and later forming adhesions at that point The angle is narrow (chamber shallow).

The depth of the chamber may sometimes be equal in the two varieties It should not, therefore, be regarded as the sole criterion of the type but only when considered in conjunction with the other findings.

Narrow-angle or iris-block glaucoma is the pathological entity that underlies most cases of so-called chronic congestive glaucoma. It is usually accompanied by congestive episodes, but not infrequently it runs a purely non-congestive compensated course for many years. When it does so it is apt to be diagnosed as "chronic simple" glaucoma, and the operation used is a filtering operation instead of iridectomy (basal excision), which is absolutely indicated in this type (provided that extensive permanent adhesions have not yet formed in the angle).

It is also of practical importance, in judging the individual case, to distinguish insofar as is possible, whether the increased pressure is due mainly to obstruction (closure of the trabecular interspaces in the presence of an open angle in the first type or closure of the angle itself through the root of the iris lying in apposition with the entrance of the angle or to the trabeculum in the second type) or to disturbance in secretion.

Furthermore it is convenient for surgical purposes to divide each type into an early and late stage according to the following criteria: (1) trabecular glaucoma should be differentiated into early and late stages according to the extent, on the optic nerve, of the destructive effects of the increased pressure; (2) narrow-angle glaucoma, on the other hand, is most conveniently divided, from the surgical standpoint, into early and late stages according to whether or not permanent organic adhesions in the angle are absent or present, irrespective of the effect of increased pressure on the optic nerve.

A different operative procedure is indicated according to the type and to the stage of development as shown in the table.

Chronic Glaucoma.—*Trabecular Glaucoma.*—In the early stage in which signs of mechanical obstruction predominate and which can be visualized by gonioscopy in the form of a "trabecular pigment band," goniotomy may be employed to incise or remove the obstruction. In practice, however, it is rarely indicated, since miotics are usually sufficient, in this early stage, to control pressure over a long

[1] Trans. Pacific Coast Oto-Ophth. Soc , 1941
[2] Digest Ophth and Oto-laryng , January, 1942.

period of time. Obliquity of the angle wall also may offer technical difficulties to successful goniotomy. In the occasional case, however, it is highly successful. In the later stage there is need for more radical interference. In this situation, cyclodialysis or external fistulization is indicated, since they are more dependable in bringing about prompt permanent reduction of tension. In other words, the trabecular obstructive type calls for goniotomy or a filtering operation according to whether or not the case is in the early or late stage.

If the case is of the predominantly secretory or neurogenic variety in which signs of obstruction in the trabeculum are not demonstrable, and there is no urgent indication for operation, one may try miotics and watch for early signs of progressive excavation of the optic nerve with loss of field. If and when such a condition occurs or threatens, adequate cyclodialysis is, in the writer's opinion, preferable to the external fistulizing operations

	PATHOLOGIC ANATOMIC CHARACTERISTICS		CLINICAL CHARACTERISTICS	OPERATION
TRABECULAR GLAUCOMA	Increased pressure due to reduced outflow caused by obstruction (reduced permeability) in trabeculum, disturbance of secretion, or both. Angle open (wide)[12] A. C. not abnormally shallow.	1. Obstructive — Early Stage	Usually compensated (non-congestive). Sometimes slight congestive symptoms. Angle open (wide). A. C. of normal depth or deep (never abnormally shallow).	Goniotomy
		1. Obstructive — Late[14] Stage	Usually compensated. Sometimes congestive. Angle open (wide). A. C. of normal depth (not abnormally shallow). In the later stage of "absolute glaucoma" secondary changes may take place in the angle.	Cyclodialysis. External Fistulizing.
		2. Non-Obstructive (Secretory)	No sign of obstruction; retention due to changed composition of secretion or hyper-secretion.	Cyclodialysis or External Fistulizing.
		3. Congenital or infantile (Buphthalmus or Hydrophthalmus)[15]	Often decompensated (sub-acute or acute with hazy cornea)	Goniotomy if cornea is transparent because iridic Angle[15] External Fistulizing Cyclodialysis[15]
		4. Juvenile Glaucoma[16]	Usually compensated	Cyclodialysis. External fistulizing. Goniotomy
NARROW ANGLE (IRIS BLOCK) GLAUCOMA	Increased pressure due to obstruction or closure of angle by root of iris, combined with secretory factor. Narrow or closed angle. A. C. Shallow.	Early Stage	Usually compensated, occasional slight periods of decompensation. (Prodromal) Angle narrow. A. C. shallow. Acute attack may develop on provocation. (See below) (Some cases may stay compensated for years and no adhesions develop).	Modified Peripheral Iridectomy (single or multiple), with deepening of chamber. Iridectomy (peripheral with keratome). Iridectomy (peripheral) ab externo. Iridotomy of Curran
		Late Stage	Frequently decompensated. Angle extensively closed by adhesions. A. C. Shallow.	Cyclodialysis; Iridectomy preceded by freeing of adhesions in angle (Reese, Jervey, Tor... External Fistulizing
	"ACUTE GLAUCOMA" Is an attack of congestion in the narrow angle shallow chamber type due to or associated with sudden complete closure of the angle by the root of the iris.	Early Stage	Sudden decompensation. Angle suddenly closed throughout its circumference with adhesions forming but not yet permanent. A. C. very shallow.	Iridectomy with kerato... (Peripheral or total). Or iridectomy ab exte...
		Late Stage	Permanent decompensation. Angle completely closed by permanent adhesions. A. C. very shallow	Cyclodialysis. (Cyclodialysis with iridectomy) (Iridectomy)

Choice of operation in glaucoma. Based on pathological anatomical classification. From Am. Jour. Ophthalmology. (Barkan.)

Narrow-angle (Iris-block) Glaucoma.—In the early stage basal excision of the iris (iridectomy in modified form) is indicated.

In many cases gonioscopic examination following classical iridectomy reveals adhesions in the angle. This accounts for many unsatisfactory results in the past. A tag of the iris root may remain. The pillars of the coloboma are frequently found to be adherent to the angle wall or to be entangled in the inner lip of the wound, thus increasing closure of the angle and obstruction. Other poor results following iridectomy are due to the operation having been performed in the wrong type of case—namely, in trabecular glaucoma—because of the presence of some congestive symptoms. Gonioscopy shows that in an effective iridectomy the iris has been completely excised down to its root. To secure this result and to prevent adhesions in the angle the writer has suggested a procedure which is a modification of periph-

eral iridectomy and might aptly be termed basal excision of the iris with deepening of the anterior chamber. It is indicated in those cases in which there are not yet extensive permanent adhesions in the angle and in which the chamber is so shallow as to require deepening for the execution of a perfectly basal peripheral iridectomy.

In the late stage of narrow-angle (iris-block) glaucoma in which the angle has been obliterated in large part or totally by permanent adhesions I have found cyclodialysis to give the best results. External fistulizing operations may also be used but they are beset with disadvantages in this type and stage. Space does not permit an elaboration of these disadvantages at this time.

The above discussion is intended to apply only to the typical acute attack in narrow-angle (iris-block) glaucoma. A stage of congestion simulating the acute attack in narrow angle (iris-block) glaucoma can also develop in trabecular (open-angle) glaucoma. It can, however, be distinguished either by the depth of the chamber or by the history and its previous course. It should not be confused with the narrow-angle type, for in the congestive stage of trabecular glaucoma iridectomy is of no avail, unless, accidentally, a filtering scar develops or what is still more unlikely the incision passes through the trabeculum and results in drainage from the anterior chamber into Schlemm's canal.

Compensation and Decompensation.—Compensation and decompensation, congestion or absence of congestion, do not denote different varieties of glaucoma but different stages of the disease. They may occur in both the trabecular or narrow-angle type, although they are more commonly present and more pronounced in the latter.

IRIDECTOMY IN GLAUCOMA (see pages 574 and 754)

Sulzer's series of 149 acute inflammatory glaucoma cases showed 73.5 per cent as improved. Wygodski's series of 147 cases of inflammatory glaucoma showed 10 per cent as improved, 40 per cent as unchanged, and a failure in 50 per cent. The same operator's series of 104 cases of simple non-inflammatory glaucoma showed that 52 per cent deteriorated after iridectomy, 10.5 per cent remained unchanged, and 36.5 per cent of the cases became blind, *i. e.*, of this series, less than 1 per cent of simple primary glaucoma was improved following a simple iridectomy. Hahnloser and Sidler presented a series of 172 eyes observed not less than ten years after iridectomy. In their cases of acute inflammatory glaucoma 64 per cent improved, 13 per cent remained relatively good, and 23 per cent were blind. The results of the same operators in chronic inflammatory glaucoma were 30 per cent improved, 27 per cent relatively good, and 43 per cent blind. In simple primary glaucoma 42 per cent of the cases showed improvement. Knapp's series of iridectomies showed an improvement in less than 50 per cent of instances. In the series of acute inflammatory cases presented by Ploman and Granstrom,[1] over 60 per cent of the cases, when operated by an iridectomy, continued for at least three years with a tension reduced to the normal; the remaining 33 per cent had failing vision with increased tension.

In 532 operations performed at the University Eye Clinic at Helsingfors, between 1907 and 1925, an iridectomy was done in the acute cases only with a 58 per cent improvement after operation. Uthoff, on the other hand,[2] analyzed 1000 cases in which he had performed 1749 operations. Of these, 1405 were iridectomies. In the acute inflammatory cases, iridectomy gave a definite lasting success in 88.6 per cent of instances, while in simple non-inflammatory primary glaucoma, he obtained 75 per cent of successes.

[1] Acta Ophth., 10, 54, 1932.
[2] Klin. Monatsbl. f. Augenh., September, 1921.

SCLERECTOMY FOR GLAUCOMA (see page 769, also page 526)

Meller's survey of 389 Lagrange sclerectomies, done by himself, showed the following end-results. Acute inflammatory glaucoma was present in 12 per cent of instances, chronic inflammatory glaucoma in 61.5 per cent of instances, simple glaucoma in 9 per cent of instances, and recurrences in 11.3 per cent of all cases. Of the recurrences, there were 14.3 per cent of simple glaucoma, and 6 per cent of chronic inflammatory glaucoma. Good results were obtained in 70 per cent of all cases. Knapp's results showed 85 successes in a series of 95 cases The series at Helsingfors showed a 70 per cent success for this group. The series from the Budapest First University Eye Clinic indicated anterior sclerectomy as the operation of choice in juvenile glaucoma, and the iridosclerectomy of Lagrange as the operation of choice in glaucoma simplex with cupping of the nerve head and with constricted fields. Lagrange's own analysis in 1922[1] of 104 cases showed 85 per cent success in cases of chronic glaucoma, using the fistulizing method, while a simple iridectomy gave only from 25 to 30 per cent of successes. His experience, however, was not based wholly upon the utilization of the sclerecto-iridectomy, as devised by himself, but included other fistulizing methods either by a simple limbal anterior sclerotomy or by a sclerotomy with peripheric iridectomy or by the sclerecto-iridectomy. Of these 104 cases, 59 had constant hypertension, 29 were treated by sclerecto-iridectomy (25 of them successfully), 15 with sclerectomy with an iritic buttonhole incision (13 successfully), 15 by simple sclerectomy, 13 successfully. Of the other 45 cases of chronic glaucoma, with intermittent hypertension, 25 were treated by sclerecto-iridectomy, 22 successfully; 4 by sclerectomy with iritic buttonhole incision, 3 successfully; and 16 by simple sclerectomy, with 13 of them successful.

The multiple or grill-like sclerotomy of Weicherkiewicz, which for many reasons is now uncommonly done but which is essentially a fistulizing operation, showed, according to Karelus, 88.7 per cent of successes in chronic congestive and simple glaucoma as compared with only 33.7 per cent of successes with iridectomy. Even Handmann's scleral-corneotomy[2] which seems surgically unsound because of the probability of adhesions of the iris to the corneotomy, gave 29 satisfactory fistulizing operations on 36 eyes. Ruszkowski analyzed 100 consecutive Lagrange operations for *simple and chronic glaucoma,*[3] *and of these* 52 per cent remained stationary. After the operation 11 per cent resulted in a reduction of visual acuity a[illegible] 38 per cent in an improvement in visual acuity. The fields of vision [illegible] mained stationary in 64 per cent, widened in 28 per cent and became m[illegible] contracted in 8 per cent of cases.

CORNEO–SCLERAL TREPHINING ([illegible] page 746)

Wilmer's series of corneo-scleral trephinings pre[illegible] 1927, incl[illegible] 107 cases observed for from three to fifteen years; [illegible] of his [illegible] showed complete success. The average of the ocu[illegible]s befor[illegible] operation was 44 mm. Hg and after the operation [illegible] 14 [illegible] Hg. In the light of his satisfactory results he di[illegible]

[1] Presse méd., May 21, 1922
[2] Klin. Monatsbl. [illegible]enh., 73, 30, 1[illegible]
[3] Kl[illegible] Monats[illegible]nh., 76, 316, [illegible]

exclusively. In the University Eye Clinic at Helsingfors, the best primary results were obtained by corneo-scleral trephining, that is, 83 per cent of successes, though almost equally good results were obtained on the group in which the iridencleisis operation was performed, that is, 78 per cent of successes. In recent years the sclerecto-iridectomy procedure, whether done according to the original technique of Lagrange or with punch forceps, has been receding in popularity and is being replaced more and more by Elliot's corneo-scleral trephining, and this in even more recent years by iridencleisis. Successes by sclerecto-iridectomy cannot be denied, but it is limited in use by reason of certain specific contraindications, and because a higher incidence of complications follows it than with corneo-scleral trephining.

Denti[1] states that one must make definite distinctions between a filtrating and a cystoid scar. Uveal tissue is present in the latter of the two but not in the former. From his observation, unless tissue from the iris or the ciliary body is incarcerated in the operation wound, the sclera becomes completely cicatrized and the results of the surgery nullified. If so, the sclerectomy of Lagrange should be used only as an operation of last resort. The writer's experience, in his analysis of the five-year-old results from glaucoma surgery, discovered that the incidence of cataract following a Lagrange sclerecto-iridectomy was higher than after any other type of fistulizing operation. The wide opening of the anterior chamber, the broad sclerectomy and the subsequent iridectomy, all are factors which singly or together may be responsible. It certainly seems that the small and accurately placed 1.5 mm. to 2 mm. corneo-scleral trephining opening, with its less violent evacuation of the anterior chamber, and with its small peripheral iridotomy or iridectomy, is less disturbing to the anatomical structures in the anterior segment of the eyeball. This analysis and personal experience has compelled the acceptance of Denti's implication relative to sclerecto-iridectomy.

IRIDENCLEISIS (see page 736)

The operation of iridencleisis, the logical successor to iridotasis, is showing increasingly satisfactory results through its use. Formerly, iridotasis and iridencleisis were operations hemmed about with many qualifications as to the type of case in which they were to be used. The procedure was considered surgically unsound by many capable ophthalmologists, in that the incarceration of uveal tissue was of itself under other circumstances an often-mentioned cause for glaucoma. The inconsistency of a similar procedure deliberately performed as a cure for glaucoma seemed too evident. The results obtained compare favorably with all other forms of fistulizing surgery.

Iris incarceration operations cannot and need not replace a trephining. The faults found with trephining are surmountable. Fuchs, A.,[2] stated that, while he had done over 1000 trephining operations, he had abandoned the operation on account of late complications. On the other hand, Davenport,[3] quoted by Bulson,[4] stated that in considering the after-results in

[1] Formation of Cicatrices After Lagrange Sclerectomy, Soc. ital di oft, p. 208, 1925.
[2] Am. Jour. Ophth., 7, 49, 1924 [3] Brit. Jour Ophth., 8, 849, 1926
[4] Discussion on Late Operative Results in Glaucoma (Spaeth), Trans Am Acad Ophth and Otolaryng., 1928

405 patients upon whom the trephining was performed, 80 per cent were apparent successes and 4.5 complete failures were reported. There were 14 cases of late infection and quiet iritis was reported as a sequel in most all of the cases. This matter of quiet iritis will be considered later under the technique on that procedure. In the same discussion as above, Bulson speaks of Galetski-Olin's analysis of 258 cases, seen in the Gronhon's clinic, during the period of fourteen years.[1] There were 197 trephinings and 38 iris inclusion operations. They report that iris inclusion operations appear to be the least difficult operation technically and the least liable to postoperative complications. The pressure is normalized in at least 90 per cent of instances. After trephining operations, the pressure was rendered normal, whereas after iridotasis, oftentimes it was subnormal. Gjessing reviewed[2] Holth's iridencleisis operations for a period from 1911 to 1924 inclusive. The cases were reëxamined after a period of from eight months (the minimum) to one hundred and sixteen months (the maximum). Of the original cases, not quite 90 per cent were thus reëxamined. His findings showed preserved or increased vision present in 86 per cent of instances, preserved or increased field of vision in 78 per cent of cases, and normal tension in 82 per cent of cases. His conclusions, based upon this analysis, were as follows: (1) the maximum result will be established within six months after the operation; (2) the operation gives a relatively certain and lasting result without exposing the eye to any considerable risk; because when the operation is properly performed no thin bleb is formed, the corpus ciliare is never exposed to such an extent as occurs with the Elliot corneo-scleral trephining; both these factors tend to prevent late infection, and hypotension is not seen; and finally (3) the cosmetic result is good, the pupil being but slightly dislocated and glare thereby avoided. Holth described his operative procedure for acute and chronic glaucoma as iridencleisis, in that it was an incarceration of the iris plus a destruction of the sphincter. In 640 operations, Holth,[3] in his private practice, over a period of twenty-five years,[4] did 223 iridencleisis operations, 268 punch forceps sclerectomies, and 140 Elliot corneo-scleral trephinings. Iridectomies, carried out for primary acute glaucoma as well as those for secondary, and above all for uveitic glaucoma, were not included in this series. Holth's conclusions on his own operation follow herewith verbatim.

> In only 50 per cent does a tension become at once and permanently normal. In 35 per cent one must use miotics from a fortnight to half a year after the operation to keep the tension normal. In both of these instances the resulting "filtering scar" will nearly always last for a lifetime. In the remaining 15 per cent the continued use of miotics, which are useless before the operation, will keep the operation normal in most cases and as a rule reoperation can be avoided.

Holth[5] further states:

> Atropine—a valuable prophylactic and remedy against "quiet iritis" after trephining and safely employed until the subconjunctival scleral defect is closed by cicatricial scar tissue—has never been used after iridencleisis for glaucoma in the University Eye Clinic at Oslo or by Gjessing or myself.

[1] Galetski-Olin: Klin. Monatsbl. f. Augenh., January and February, 1922.
[2] Acta Ophth., January, 1925.
[3] Klin. Monatsbl. f. Augenh., 79, 620, 1927.
[4] Iridencleisis cum Iridotomia Meridionali, Arch. Ophth., vol. 4, No. 6, December, 1930.
[5] Arch. Ophth., vol. 9, No. 6, June, 1935.

Gjessing at times uses 10 per cent or 1 per cent homatropine to obtain a suitable mydriasis, but never atropine. Holth routinely uses 2 per cent pilocarpin, once or twice a day for six months, beginning a fortnight after the iridencleisis, especially for those patients from outlying districts in whom active postoperative observation is not possible. After iridencleisis, Holth found late infection in only one instance, a case of glaucoma absolutum in which (after the patient had refused the proposed enucleation) he did an iridencleisis. The late infection occurred two years after the operation, terminating in panophthalmitis. He feels that the greatest reason for the absence of late infections after iridencleisis is to be found in the fact that the subconjunctival end of the iris fistula is always placed further from the limbus than is the sclerectomy fistula, even if the anterior chamber is shallow.

Joseph Blaickner[1] analyzed the cases done, according to his technique for iridencleisis; his conclusions as to the contraindications were as follows: juvenile glaucoma, a swollen lens, and cases which might require future cataract extractions or in which the lens was dislocated.

Holst[2] analyzed 534 iridencleisis operations done at the Oslo clinic. One case of sympathetic ophthalmia occurred, cystic scars were present in 17.1 per cent of instances, and in 42 per cent of all the cases posterior synechiæ were noted, though apparently without injurious effects in so far as the vision or the tension was concerned.

Any text-book which has as its aim encyclopedic explanations, must eschew personal likes and dislikes, that is, it should carefully remain without prejudice. If an opinion can be properly expressed herein, based not wholly upon personal experience, but also upon the detailed analysis of the literature relative to a comparison of fistulizing operations for the treatment of acute and chronic primary glaucoma, an order of preference at the present time, shows interesting variations based upon three points: (*a*) the frequency with which the operation is done, (*b*) totals of success, and (*c*) the contraindications and the complications. With (*a*) corneoscleral trephining is first, sclerectomy second, and iridencleisis is third. With (*b*), that is the successes (whether followed by miotics or not), an iridencleisis and corneo-scleral trephining are about the same, with sclerecto-iridectomy third. In so far as (*c*) is concerned, that is, the one with *the fewest contraindications and complications for the case,* iridencleisis is first, with corneo-scleral trephining and sclerecto-iridectomies a second and third in that order, though not widely separated one from the other.

In comparing iridencleisis and corneo-scleral trephining, it resolves itself wholly into a comparison of three rather important factors: (1) to weigh carefully the possibility of sympathetic ophthalmia from iridencleisis, against that of quiet chronic iritis, and late infections with corneo-scleral trephining. Baer (Philadelphia), in a personal communication, described 2 cases of sympathetic ophthalmia following iridencleisis which came to his office from outside sources; (2) the fact that iridencleisis lends itself better to the lower ranges of tension while corneo-scleral trephining seems to be more applicable to the higher degrees in tension; and (3) certain salient factors connected with each case, as the presence of incipient cataract, the nervous and mental stability of the patient, the manual dexterity neces-

[1] Ztschr. f. Augenh., October, 1930.
[2] Acta Ophth., 12, 348, 1934.

sary for the two operations, and undoubtedly the possibility of maintaining continued postoperative observation in the case. In citing the disadvantages of trephining, Butler considered it a more serious insult to the eye than iridencleisis. He feels that this is true when a 2 mm. trephine is used and, further, he seems to regret that the worst cases of glaucoma are selected for the operation. One can hardly agree with this, for in all except extraordinary cases one uses a 2 mm. trephine most commonly, and the worst cases are probably those for which the trephining is best indicated. Certainly a larger bleb frequently does follow trephining than follows iridencleisis. Hypotonia is also to be considered here. Moderate degrees of this are of no clinical significance. Perhaps the graver degrees of hypotonia are a factor, but still hypotonia is seen, so extreme in degree that the weight of the lid indents the eyeball, and still these remain for years free from complications. The postoperative period is more serious with trephining than for iridencleisis, but postoperative care in trephining, while rigid, cannot nullify the operation so completely as will improper postoperative care ruin the results of an iridencleisis. This includes miotics, on the one hand, with mydriatics on the other, early massage, and later the use of mild bactericidal eye lotions of metaphen, mercurophen, and of zinc sulphate.

Cases operated with a sclerecto-iridectomy seem to show the highest percentage of complications. On the other hand, repeatedly in the literature one finds the statement that this operation also is often considered the last to be done in an intractable case. This practice may be, almost wholly, the reason for this unfavorable observation.

The histology and histopathology of filtering blebs for glaucoma surgery have been rather extensive. Holth,[1] Lohlein,[2] and Verhoeff[3] reported histopathological findings. The writer, in 1932, carried through a series of iris inclusion operations on the eye of the rabbit.[4] The development of the fistulizing bleb was plainly outlined and illustrated. Figure 460, *A*, shows a developing cystoid cicatrix three months after the operation. The split in the cornea anterior to the incarceration is an artifact from the fixation. The incarceration plug is made up of iris tissue showing degenerated pigmented epithelium. There is some incarceration of the ciliary body because of the normal iris and ciliary body relationship in the rabbit. With the high power considerable proliferation of fibrous connective tissue can be seen as in *B*, with the formation of many new-formed thin blood-vessels in and about the ciliary body. Another section, *C*, is six months after the operation; *D* is the high power. A typical cystoid cicatrix is developing. The iris lies between the clearly cut edges of the sclera, showing thin-walled spaces lined with pigment epithelium, and one can see the definite elevation of the entire cystoid cicatrix above the level of the sclera. Microphotographs of a cystoid cicatrix nine months after the operation are seen in *E* and *F*. The formation of thin-walled spaces lying beneath the epithelium is plainly visible, with reflection of the epithelium upon these.

[1] Anatomical Examination of Six Cases of Subconjunctival Fistula Scars From Five Months to Six Years After Successful Iridencleisis, Brit. Jour. Ophth., vol. 6, January 10, 1922.

[2] Review of the Literature, Zentralbl. f. d. ges. Ophth., 22, 1, 1929.

[3] Histologic Findings After Iridotasis, Arch. Ophth., 45, 5, 1916; Am. Jour. Ophth., 7, 373, 1924.

[4] Spaeth Iris Inclusion Operation in the Eye of the Rabbit, a Histologic Study, Arch. Ophth., 8, 550, 1932 (see bibliography attached thereto).

There is some pigment in the sclera as well as in the corneal stroma; *F* is the high power of the anterior wall of this cystoid cicatrix, showing the

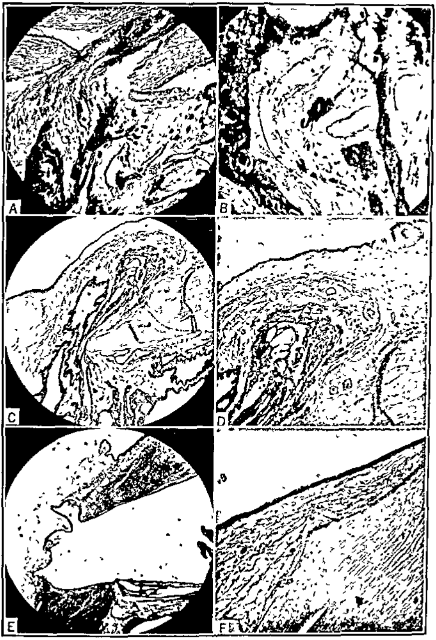


FIG. 460.—Microphotographs of developing filtering cicatrix: *A*, three months after operation; *B*, same with high power, showing many newly formed blood-vessels; *C*, six months after operation; *D*, the same high-power magnification; *E*, microphotographs nine months after operation; *F*, high power of the anterior wall of this cystoid cicatrix, showing the atrophic iris stroma covering the cut edge of the cornea with cut edge of Descemet's membrane terminating in the wall of the cicatrix. (Operation: Iris inclusion.)

atrophic iris stroma covering the cut edge of the cornea with the incarcerated end of Descemet's membrane terminating in the wall of the cicatrix.

The microphotographs together portray histologically the course through which the tissue passes in forming a cystoid cicatrix.

The conclusions stated in the original work and based upon only the histological study are here abstracted.

(1) The iris epithelium plays a definite rôle in the process of filtration, its presence being absolutely essential toward maintaining a permanent fistula. (2) It seems that in general the final histological appearance of a filtering cicatrix or a cystoid cicatrix is approximately the same regardless of whether it resulted from an iris inclusion operation, from a sclerecto-iridectomy, or from a corneo-scleral trephining. The results depend upon the development of a pigment-lined cicatrix. Failing this essential, the sclerectomy performed ultimately closes without filtration. (3) Upon a histological basis alone iridencleisis is a proper surgical procedure. Histologically, it seems that of necessity the permanent results must be somewhat delayed as compared with the abrupt results of the sclerectomy or the more quiet results of a corneo-scleral trephining. This fistula will remain open permanently and will thus compare favorably with the duration or age of similar cicatrices of the other operative procedures without developing a secondary closing non-filtering cicatrix. (4) There is a doubt whether an iridodialysis, which was also performed in combination with some of these instances, plays any important part in the permanent results, though it does simplify the amount of incarceration present and permits an early eversion of the iris. Too often the immediate hæmorrhage which occurs is an unwanted complication

Holth,[1] in discussing the histology of a fistula following anterior sclerectomy, reported 9 cases after a successful operation (following the unrelated death of the patient) from eight months to six years after successful iridencleisis. His conclusions are based upon a relationship that iridencleisis may have with anterior sclerotomy and with anterior sclerectomy. They are as follows:

(1) The best conditions under which the subconjunctival fistula following anterior sclerectomy may remain open for many years are provided when the walls of the defect are covered by uveal pigment epithelium. (2) To gain this object it is necessary that an ordinary or a basal iridectomy be performed immediately after the sclerectomy. The immigration of the pigment epithelium cannot be depended on, however, and it never takes place after an isolated anterior sclerectomy. Exceptions to this rule are cases in which there is a postoperative prolapse of the pupillary edge. (3) The practice of combining anterior sclerectomy with iridencleisis must, however, be discouraged. The spontaneous immigration of the isolated pigment epithelium, which is often seen, is less risky than inclusion of the whole thickness of the iris under the thinnest conjunctiva at the limbus corneæ. (4) After Holth's iridencleisis through an extralimbal, subconjunctival keratome incision the iridial fistula will regularly open from 2 to 3 mm. from the limbus under a thicker cover of conjunctiva. (5) The scleral beak protects the ciliary body against secondary atrophy. (6) Iridencleisis cum iridotomia meridionali should always be performed alone—never combined with anterior sclerectomy.

In speaking of the after-treatment of iridencleisis as compared with the after-treatment of corneo-scleral trephining, Holth[2] was emphatic in explaining the reasons for the contraindications of atropinization in iridencleisis. As stated before, in his clinic at Oslo and in Gjessing's clinic at Helsingfors, pilocarpin is prescribed in a 2 per cent solution to be instilled once or twice a day for six months, beginning a fortnight after the iridencleisis. Atropin is necessary after trephining as a valuable prophylactic and remedy against postoperative iritis and could be safely employed probably until the subconjunctival scleral opening was closed by cicatricial scar tissue.

[1] Arch. Ophth., vol 6, No 2, August, 1931.
[2] Arch. Ophth., vol. 7, No 6, June, 1933.

Paralysis of the sphincter muscle by atropin, however, following iridencleisis, may result in pulling the iris from the scleral wound. This was demonstrated by Lowegren[1] in iris prolapses through traumatic wounds of the corneal periphery.

CYCLODIALYSIS (see page 480)

Cyclodialysis was first presented by Heine while working as an assistant in the clinic of Uthoff of Breslau.[2] The operation by Heine was originally postulated on observations by Fuchs (E.) and by Axenfeld, that choroidal detachment combined with the formation of a sinus into the anterior chamber should establish a lasting communication between the anterior chamber and the supra-choroidal space. The success of the operation is unquestioned; the mechanics of it, however, are not as clear-cut and as simple as was thought by Heine. Stoughtenborough, at the Graduate School of Medicine, University of Pennsylvania, in 1924 showed with his histological studies upon the normal eye of the rabbit that permanent supra-choroidal space drainage did not remain. The immediate evacuation of the anterior chamber through this space acts as an early paracentesis of the anterior chamber for the immediate postoperative lessening of the ocular hypertension. The beneficial results of this are apparently also continued by a subsequent decrease in the formation of the aqueous. Microscopically the operation shows nothing but a partially detached degenerated ciliary body. The same fact applies in the histological studies from a human eye. Stoutenborough failed to find any atrophy of the ciliary body at the site of the operation. Wessely[3] felt that though the theoretical basis of the cyclodialysis of Heine has been invalidated since the change in our views was brought about by Fuchs, this does not involve the abandonment of Heine's fundamental idea. Animal experimentation, apparently, and histological investigation limited almost wholly to the results of unsuccessful operations, can prove nothing. Weekers, Krouss, and Joudin found no communication between the anterior chamber and the supra-choroidal space, though they did find a cicatricial adhesion of the ciliary body to the overlying sclera. Salus, quoted by the author,[4] analyzed a series of 456 consecutive cyclodialyses. They included cases of both inflammatory as well as non-inflammatory glaucoma and were followed with successes in over 80 per cent of instances. Schmidt, of the Erlanger Universitats Augenklinik, in 1927 analyzed 60 consecutive operations with success in 53 instances. One case with severe vitreous hæmorrhage was unsuccessful. Some cases with a partial iridodialysis, it seemed, were not harmed by this complication. Occasionally, a partly denuded bit of Descemet's membrane fell to the bottom of the anterior chamber without modifying the results. De Grósz performed over 1000 cyclodialyses, and he found no severe uveal inflammation in any of them, nor were there any cases of subsequent sympathetic ophthalmia seen. He selects this operation first for chronic non-inflammatory glaucoma. Elschnig and Gradle, as well as others, feel that the operation is indicated in all forms of primary glaucoma except in the inflammatory glaucoma of the non-compensated type.

[1] Ogonsjukdomarne, 2d ed., Stockholm, p. 161, 1900.
[2] Deutsch. med. Wchnschr., 21, 824, 1908.
[3] Ztschr. f. Augenh., 47, 35, 1922.
[4] Late Operative Results in Glaucoma, Trans. Am. Acad. Ophth. and Otolaryng., 1928.

Certainly the operation must not be considered as a last and final resort. Actually those successes which have occurred with this procedure when it is utilized as a last resort are perhaps the greatest recommendation for it, and the failures which are certain to occur under such circumstances should not be held against it. Almost universally operators grant it an incidence of successes in well over 60 per cent of all cases. It is remarkable when one considers the unwise selection of cases, too often seen when utilizing the operation, that the percentage of success, even in the average, is so high. Individual successes range from 45 to 90 per cent in all cases, as found by different operators. The reasons for considering the procedure a valuable one in glaucoma therapy are based upon its ease of technique and relative absence of complications; upon the fact that it can be repeated three or four times; it does not render impossible other operations, as an iridectomy, a trephining, or a lens extraction, and the operation is not followed by any cosmetic defect. Elschnig, the greatest recent exponent and authority on this operation, reports 8 per cent reoperations for the second and third repetition, but he uses the operation only for glaucoma compensatum.

Wheeler[1] is much in favor of an iridectomy combined with cyclodialysis for the reduction of ocular tension in seemingly hopeless cases of glaucoma. He feels:

That iridectomy combined with cyclodialysis offers a fair chance for the reduction of ocular tension in seemingly hopeless cases of glaucoma. The operation makes possible the removal of the root of the iris so that reformation of anterior synechiæ cannot occur It gives an opportunity for the escape of aqueous in two ways: first through possible reëstablishment of drainage through Schlemm's canal and, second, through possible permanent detachment of the ciliary body, with free access of aqueous to the cleft between the ciliary body and the sclera. In cases in which the condition is far advanced the chances of reëstablishment of the original angle drainage probably are not good, so the additional chance of permanent drainage into the cleft made by the cyclodialysis is important The operation is gratifying in glaucoma occurring in aphakic eyes which do not respond favorably to other operations It is valuable in eyes that need discission of a secondary cataract or a false membrane but have no anterior chamber or an anterior chamber too shallow to allow of the necessary manipulation for cutting the membrane. The operation results in the formation of an anterior chamber and makes possible the necessary manipulation for discission. A disadvantage of the operation is that the incision with the keratome for iridectomy is unpleasant and sometimes difficult on account of the softness of the eye resulting from the cyclodialysis and on account of hemorrhage into the aqueous chamber. (AUTHOR.—This must be removed by irrigation before proceeding with the iridectomy.)

Figure 461 is his original illustration. During his last four years he operated 57 eyes according to this technique, all with far advanced glaucoma Many of them, Wheeler states, were seemingly hopeless, and in them previous operations for glaucoma had failed.

The relationship which exists between cyclodialysis and trephining is also a very interesting one. A. Fuchs[2] presented a case which illustrates beautifully the mechanics of the two operations.

It may happen that the root of the iris has become adherent to the pectinate ligament and to the posterior surface of the cornea, as in cases of long-standing glaucoma. This is important to bear in mind in connection with iridectomy *ab externo*.[3] If, making a hole in the sclera with the trephine, one immediately cuts

[1] Arch. Ophth., vol 16. No. 4, October, 1936.
[2] Arch. Ophth., vol. 16, No. 3, September, 1936.
[3] Salzmann-Fuchs: Surgical Treatment for Iridocyclitis, Arch. Ophth., II, 591, April, 1934.

through the iris, which may be entirely atrophic and consist possibly of only the pigmented epithelium, the fluid runs out of the posterior chamber, but no vesicle of the iris appears. Enlargement of the incision is of no aid. In one case in which I (Fuchs) encountered this complication in iridectomy *ab externo* I resorted to cyclodialysis in the region of the operative incision in order to get the iris free from the periphery. I did not, it is true, succeed in freeing the iris and causing it to protrude, but I did succeed in freeing the angle of the anterior chamber and producing a fistulous scar. The case was unusual because the patient had had for four weeks an acute attack of glaucoma affecting both eyes. Profiting by this experience, I (Fuchs) performed cyclodialysis in the other eye. Both eyes reacted to the operation as well as could be expected considering the difficulties of the situation.

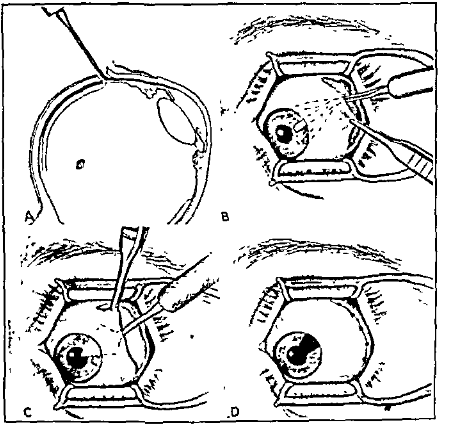


Fig. 461.—Iridectomy combined with cyclodialysis. *A*, showing anterior angle synechiæ; *B*, introduction of cyclodialysis spatula, and its rotational excursion, *C*, keratome incision, *D*, completion of case (Wheeler.)

The complications of this technique as for all the various operations will be discussed in the consideration of the technique of that operation. Recurrent operative glaucoma is usually less severe than that formerly present. A brief comparison, however, of recurrent or exacerbated glaucoma as a result of surgery is relevant here. By this is not meant failure in surgery, but malignant glaucoma. In such instances a few days after the operation, regardless of the type of surgery done, the eye becomes hard, the visual capacity as a rule is rapidly destroyed, with extremely severe subjective symptoms,[1] the anterior chamber is completely lost, both eyes are usually affected in the same way by the operation, and the condition defies all

[1] Majkseh: Ztschr. f. Augenh., 52, 157, 1924.

efforts of treatment. If an iridectomy is performed the wound gapes and the lens is jammed against it. Trephining is quite hopeless. An attempted sclerectomy and especially sclerecto-iridectomy is followed by the same course of anatomical complications as with an iridectomy. It seems that this type (though the condition is fortunately extremely rare) of recurrent exacerbated malignant glaucoma and the other intractable forms of glaucoma follow, most commonly, first, after Heine's cyclodialysis; second, after trephining; and last, after sclerecto-iridectomy and iridectomy. In the first instance, that is, relative to cyclodialysis, Yoshida[1] believes it to be caused by a severe swelling of the ciliary body due to the trauma. Early after cyclodialysis, the tension frequently rises the least bit before the subsequent fall develops. This may be the proof of Yoshida's contention, in that it is the usual response to lesser degrees of traumatism, or it may be a pathologically increased tissue response to similar degree of trauma. Its clinical importance should not be underestimated. In cases of corneoscleral trephining, the complication occurs in those instances wherein an unruly, non-coöperative, or even simply restless patient prolapses the iris into the trephine opening. Not only is there no filtration as a result, but in addition to the uncorrected hypertension, one has added thereto the traumatism of the surgery, the postoperative pain, and the iritic irritation resulting from a globular non-filtering subconjunctival cyst of prolapsed iris. This type of cicatrix is readily distinguished from the satisfactory multilocular filtering bleb of satisfactory cases. Further surgery is absolutely necessary, a second trephining must be done lateral to the iris prolapse, and then either immediately thereafter or at some early future date this iris prolapse is to be resected with the overlying conjunctiva, the edges of the scleral opening cleansed of iris and uveal tissue by the application of the cautery, and the wound closed by scleral sutures and with a conjunctival flap above these. In sclerectomy and iridectomy an acute lens swelling from the traumatism of the surgery is rather likely the cause for a sudden and immediate recurrent glaucoma. The complication is difficult to handle and may demand an immediate lens extraction.

Gradle,[2] in his critique of glaucoma operations, speaks of the surgical procedures as being three-fold.

"1. Operations to restore the normal intra-ocular paths of drainage.

"2. Operations to open new intra-ocular paths of drainage.

"3. Operations to form paths for extra-ocular drainage."

Iridectomy and its various modifications are the main examples of the first class. As Gradle says, a properly performed iridectomy, no matter whether performed with a keratome or with a Graefe knife, or scalpel *ab externo*, must remove the root of the iris sufficiently peripherally so that posterior pressure cannot find any iris tissue to jam into the chamber angle. Under Type 2, the only operation which is to be logically considered is a cyclodialysis. As will be discussed later under cyclodialysis, Gradle feels that Heine's original contention still stands, "That the modus operandi of the operation was the opening of supra-choroidal spaces whence the aqueous could be absorbed into the blood stream." The anatomical studies of Elschnig, within the past two years, seem to confirm this. The oper-

[1] Am. Jour. Ophth., 6, 356, 1923.
[2] Am. Jour. Ophth., vol. 18, No. 8, August, 1935.

SPECIFIC OPERATIONS AND INDICATIONS THEREFORE

Operation	Simple Non-inflammatory	Acute Congestive	Chronic Congestive	Secondary Glaucoma	Absolute Glaucoma
Iridectomy, peripheral or complete		Acute stage when no response has been obtained from medical treatment		a. Postoperative iris prolapse b. Anterior synechiae c. Iritic and uveitic glaucoma. d. Glaucoma with occlusion of the pupil e. With intumescent lens as well as other lens injuries	
Transfixion of the iris				Iris bombé	
Corneal paracentesis		Glaucoma of iritis and iridocyclitis.		a. Acute stage of secondary glaucoma. b. Secondary iritic glaucoma. c. Sympathetic ophthalmia with glaucoma	
Posterior sclerotomy	As an initial procedure in grave hypertension		As an initial procedure in grave hypertension	In acute hemorrhagic glaucoma multiple sclerotomies may be done.	As a vitreous fistula may postpone the time of enucleation.
Sclerotomy of Barkan	Outstanding indications according to Barkan If contact glass confirms presence of a normally appearing anterior chamber angle	To be considered in the interval stage as an initial operation.			
Anterior sclerotomy, anterior sclerectomy, sclerecto-iridectomy (Lagrange) and similar procedures	To be seriously considered in cases with hypertension in the lower ranges, contraindicated with cataract changes		To be seriously considered in cases with hypertension in the lower ranges, contraindicated with cataract changes in the lens Not to be done in one-eyed people	Often successful after failure from one or more trephinings. When synechiae are present but without ciliary injection.	
Iris inclusion operations, iridotasis, iridencleisis	In all cases of non-inflammatory glaucoma with the tension in the lower ranges of hypertension	When response from medical treatment has been fairly successful, congestive stages receding, and especially in cases of recurrent attacks oftentimes will replace an earlier anticipated iridectomy As a prophylactic operation on the uninvolved eye especially if rise in tension should occur, no matter how slight, during a period of attack in the opposite eye (Uhthoff Deutsch med Wchnschr., 49, 6, 1923).	A very satisfactory procedure especially in the presence of cataract changes and in cases in the lower ranges of hypertension	Definitely contraindicated in the presence of iritic inflammation or with a history of iritic inflammation, contraindicated in the presence of synechiae which would prevent a satisfactory incarceration	Has been done by Holth with some success.
Corneo-scleral trephining	Seems to be the operation of choice regardless of the degree of tension. May need repeating in cases of high tension	Can be used with success as the phase of congestion is leaving satisfactory for interval periods.	To be seriously considered here though the iridencleisis operation and a sclerecto-iridectomy have perhaps equal value	a. Very satisfactory after cataract extraction. b. Quite satisfactory in the presence of a non-congestive stage of iritic glaucoma c. Has held vision and tension in the glaucoma of lens dislocations	May hold absolute glaucoma but not recommended especially in the presence of anterior staphylomata.
Cyclodialysis	Very satisfactory procedure, especially in the glaucoma of the lower ranges By many men considered the ideal operation for buphthalmos	Only as an interval period procedure		In the glaucoma of cataract extraction non-congestive and when complicated by incarceration of capsule or in the glaucoma of the lower degrees of tension wherein the glaucoma may have been primary, existing prior to the lens extraction but undiagnosed	

ations which come under Group 3 are historically grouped by Gradle as follows:

1. Coccius—1859. Iridectomy with iris inclusion.
2. Argyll-Robertson—1876. Trephining of the sclera.
3. Bader—1881. Iris inclusion into scleral incision.
4. Herbert—1903. Irido-sclerectomy.
5. Lagrange—1905. Irido-sclerectomy.
6. Holth—1906. Iridencleisis.
7. Borthen—1909. Iridotasis.
8. Elliot—1909. Corneo-scleral trephining.

The surgical survivors of the formidable list of Type 3 operations seem to be, as Gradle states, Elliot's trephining, Herbert's sclerectomy, Lagrange's irido-sclerectomy, Holth's iridencleisis, and Borthen's iridotasis.

With regard to the adequacy of operations performed for different kinds of glaucoma, de Grósz[1] stated that the following principles are borne in mind at the Budapest University Eye Clinic: inflammatory glaucoma, prodromal and acute stage—iridectomy (von Graefe); chronic inflammatory glaucoma—cyclodialysis (Heine) or trephining (Elliot); glaucoma simplex—irido-sclerectomy (Lagrange); juvenile glaucoma—anterior sclerotomy (de Wecker), glaucoma, degenerative stage—enucleation (Arlt).

General rules for surgery are tabulated in chart on p. 719.

ANTI-GLAUCOMA IRIDECTOMY

Albrecht von Graefe's original article relative to iridectomy in glaucoma, comprising more than a hundred pages, appeared in 1857. In 1859 it was translated into English, appearing in "selected monographs in the new Sydenham Society." In 1929[2] the original article was again translated by Adler[3] and published in abstract, omitting all protocols of the cases, with the idea of adhering to the thought but not to the wording of the original. Adler said, "There have been few therapeutic measures in ophthalmology or medicine in general which have remained so permanent."

The iridectomy of glaucoma is rather different from an iridectomy done as a preliminary procedure to cataract extraction or as an optical iridectomy. The eye is usually painful, local anesthesia is ineffective because of the poor absorption of the anesthetic, probably due to the hypertension and to the edema of the superficial coats of the eye, and also because the patient is always more or less upset nervously. Retrobulbar injections of novocain and of adrenalin, if done ten to twenty minutes before the operation, may make a general anesthesia unnecessary and certainly lower, temporarily, the ocular hypertension present. The preoperative medication must be directed toward the glaucoma as well as toward the surgical procedure which must be carried out. The anterior chamber is shallow and it may be necessary for this reason to use a narrow blade cataract knife rather than a keratome. After the speculum has been introduced, the fixation of the eyeball depends upon whether one is using a keratome or a cataract knife. If a keratome is being used, the fixation of the eyeball should be at a point 2 mm. behind the limbus opposite to the point of entrance into the anterior chamber. If a cataract knife is being used

[1] Arch. Ophth., vol. 5, No. 3, March, 1931.
[2] Arch. Ophth., vol. 1, No. 1, January, 1929.
[3] Arch. f. Ophth., vol. 3, 1857.

the fixation had best be made at that point on the limbus where the knife blade will emerge from its counterpuncture. In this last instance the point of the knife for entrance is directed toward the sclera at a slight angle and into the sclera at this angle. The handle is then directed backwards so that the plane of the blade is parallel to the plane of the iris. The blade is passed across the anterior chamber, without engaging the iris, to its counterpuncture at the opposite limbus. If one is standing on the right of the patient and operating on the left eye, the point of entrance should be, under ordinary circumstances, at 1 o'clock and the counterpuncture at 11 o'clock. The blade is then carried upward in small sawing movements to the limbus and beyond, so that the emerging cut lies in the sclera. If this is not done an oblique shelf of corneo-scleral tissue will remain, and it will be quite difficult to obtain a satisfactory resection of the iris at its root. One must be careful not to lose the little anterior chamber which is present, otherwise a peripheral and unsatisfactory iridectomy from the knife edge may result. If the knife edge becomes entangled in the iris, it must be withdrawn and the incision completed with small blunt-pointed Stevens' type scissors, the scissors cut passing from the point of puncture to the point of counterpuncture.

The writer feels that, in general, the best position for the operator when using the keratome is always to the right side of the patient so that the tip of the keratome can be seen immediately in the angle of the anterior chamber. Many men pass a keratome from above, standing themselves at the head of the patient. Naturally much depends upon the habits formed, but it seems much more logical to hold the keratome with the thumb above and two or three fingers below, the palm of the hand facing the operator, and to draw the keratome toward you. The movement is natural, the blade can be seen, the tip of the keratome is visible the moment it appears in the anterior chamber, and it is a simple thing to keep the plane of the blade parallel to the plane of the iris. The best work is done when the eye is rotated sharply downwards. (With the operator standing above and passing the keratome from above, a sharp downward rotation complicates matters a bit.) Figure 420 is a sketch to illustrate this.

When the operator stands above and passes the keratome from above it is to be held somewhat differently. The thumb is now on the posterior part of the handle with two or three fingers upon the front of the handle, and its motion of introduction in the eye is to be one of pushing away rather than one of drawing toward oneself. (See Fig. 421.)

The former of these two maneuvers can always be utilized when making a conventional iridectomy at 12 o'clock. The latter of the two, however, must be utilized when the incision is made at the limbus laterally or medially. The less occasional iridectomy made on the limbus near 6 o'clock can be made from above simply by reversing the position of the operator, in that he is now standing above for either the right eye or the left eye. Ambidexterity in passing the keratome is not an essential nor even an advantage.

The tip of the keratome should touch the eye at least 1 mm. back of the corneo-scleral junction. If one desires, it is permissible to carry the tip of the keratome under the conjunctiva for a short distance to achieve a subconjunctival iridectomy. A small portion of the conjunctiva will then fold up over the anterior surface of the blade during the remainder of its intro-

duction into the anterior chamber. Reese was quite insistent on the necessity for a subconjunctival iridectomy. Other men feel it is of no great importance.

Post[1] also is insistent on the subconjunctival route for a glaucoma iridectomy. After instillation of cocain he balloons out the conjunctiva with a subconjunctival injection of normal saline.

The conjunctiva is then seized below the mid-horizontal line with a double fixation forceps, and a Graefe knife is introduced into the conjunctiva at a point about 3 mm. above the upper border of the limbus and in a vertical line with the temporal border of the cornea. The knife is then entered into the anterior chamber in a line directed toward the tip of the nose. The handle is then depressed and a counter puncture made at a point which will cause the finished section to be of approximately the upper fifth of the circumference of the cornea. The section is now completed upwards on a plane with the iris, the point of the knife remaining subconjunctival. At the moment of exit of the blade it is tilted somewhat forwards. The knife is then withdrawn through the original puncture wound in the conjunctiva. The bleb will still be much elevated at this period. The puncture wound is now enlarged to about 4 mm. Through this an iris forceps is passed into the anterior chamber and the pupillary border of the iris seized and drawn upwards through the limbus incision. The iris is somewhat everted by this procedure. The iris is now pulled firmly into the temporal end of the incision and that part which extends through the scleral section is excised, the scissors being introduced subconjunctivally. This completes the operation which has been performed entirely subconjunctivally.

If a flap is desired it is best to cut one with scissors and fold it down upon the cornea before the anterior chamber is opened. Fleischer[2] was one of the first to recommend this. He prefers a flap just as if an Elliot trephining were being done. After the iridectomy the flap is to be fastened with one or more sutures.

As the tip of the keratome penetrates the sclera, the blade being held almost perpendicular to the globe, until the point appears in the anterior chamber, one is aware by the decrease in resistance to pressure when the eyeball has been perforated. The handle of the keratome is then depressed posteriorly so that the plane of the blade is parallel to the plane of the iris, and the incision completed as has been previously described. Ordinarily, the incision should extend on the limbus from 11 o'clock around to 1 o'clock, or even a bit more than this. Because of the shallow anterior chamber, one must be careful that neither edge of the keratome is cutting into the clear cornea (by rotation of the handle of the keratome), also at the same time that neither edge has cut posteriorly into the ciliary body. As soon as an incision is made sufficiently large, the keratome must be withdrawn. To do this the handle is further depressed posteriorly to tip the point of the keratome away from the lens; the blade is withdrawn the least amount and the withdrawal halted for a moment. This will permit aqueous to escape slowly. The blade can then be wholly withdrawn, maintaining the same position of the plane of the blade, but withdrawing the keratome toward one or the other of the extremities of the incision in an oblique manner, that is, toward 1 o'clock or toward 11 o'clock. In this way the incision may be increased even more, if necessary, by one cutting edge of the keratome. A large incision is desired and this withdrawal enlargement of the incision

[1] Subconjunctival Iridectomy for Glaucoma, Am. Jour. Ophth., vol. 13, No. 1, January, 1930.

[2] Klin. Monatsbl. f. Augenh., 74, 163, 1923.

line is often valuable. The procedure may result in a lateral displacement of the coloboma of the iridectomy unless that is taken into consideration at the time of the iridectomy, because the mid-line of the incision will be offset to one side or the other. A pair of iris forceps and iridectomy scissors are then taken, respectively, in the left and the right hands. The fixation of the eyeball must be taken over by an assistant, especially if the case is under general anesthesia. The closed iris forceps are passed through the incision and toward the sphincter iridis. For an ordinary iridectomy the iris should be grasped at the sphincter iridis for its subsequent withdrawal; in the case of an anti-glaucoma iridectomy, however, the iris should be grasped slightly nearer to its root than this to insure a basal coloboma. The scissors should be placed close to the globe ready for cutting at the same time the forceps are introduced into the anterior chamber. The size of the iridectomy depends upon three factors: (1) the amount of iris withdrawn, (2) the position at which the iris is grasped, and (3) the position of the cutting edges of the scissors. The nearer one cuts the iris to the forceps the smaller the iridectomy; the opposite must therefore be true. The closer the scissors are approximated to the globe the larger the resulting coloboma. One may even depress the lips of the incision to obtain a larger iridectomy. Further, if the cutting edges of the scissors are held parallel to a corneal radius a smaller coloboma will occur than when the edges of the scissors are held (for cutting) parallel to the line of incision. The demands of the operation decide the position the operator must take with his scissors. With the forceps engaged in the iris this membrane is slowly but steadily withdrawn until the pupillary margin appears and the tiny black triangle of the posterior or uveal side of the iris is seen. The forceps with its engaged iris is then lifted slightly away from the eyeball so that the scissors can cut beneath the tip of the forceps, and the iridectomy is performed immediately. One clean snip of the scissors is made, not hurriedly, but smoothly, though without delay.

Bowman's anti-glaucoma iridectomy has been discussed (Fig. 462). Three snips of the scissors are necessary instead of one. The iris is first withdrawn, slightly laterally or medially, *i. e.*, toward one extremity of the incision line. A pillar for the coloboma is formed by the first cut (*A*, Fig. 462) there through the iris to the uveal triangle, with the point of the scissors directed slightly backwards toward the root of the iris. Continued traction is applied to the prolapsed iris as it is pulled toward the opposite extremity of the wound; a similar cut (*B*, Fig. 462) forms the opposite pillar of the coloboma. The third snip of the scissors completes the iridectomy. It is made, not with the tips of the scissors, as are the first and the second cuts, but with the length of the blades, these being held parallel to the line of the incision and depressing the wound slightly. One must be careful not to cut the conjunctiva nor any other contiguous tissues at this time. De Wecker, Bowman, and several others performed this form of iridectomy by tearing the iris free at its root, instead of cutting it. The last cut completes the sectioning of any iris root which was not torn free by the iridodialysis which is a part of the technique. According to Beard, cutting only the pillars is a procedure that has been attributed also to de Wecker and to Cuignet, under the name of arrachement of the iris. The next step is the replacement of the pillars of the coloboma. Any blood in the anterior chamber must first be removed by irrigation. The tip of an

irrigating syringe is placed against the posterior lip of the wound, near one of the extremities of the incision, and warm normal saline allowed to flow steadily into the anterior chamber with just sufficient pressure to permit, not droplets, but a smooth stream. In this way the anterior chamber is filled with saline dislodging the clot, and by slight pressure upon the posterior lip of the wounds the saline and the clot are evacuated. The filling of the anterior chamber and its subsequent evacuation may be carried out as often as is necessary to clear the anterior chamber of hæmorrhage. If the clot has not formed, but the blood is still fluid, the steady flow from the irrigator tip will cause little whorls of fluid in the anterior chamber, permitting entrance and evacuation at the same time. The irrigation, when necessary, may be sufficient to replace the pillars of the coloboma so that they lie free in the anterior chamber. If this does not occur, an iris spatula may be used to replace them. Patting the cornea lightly anterior to the incision will release any peripheral incarceration of the iris and may of itself be sufficient. If not, the iris spatula must be

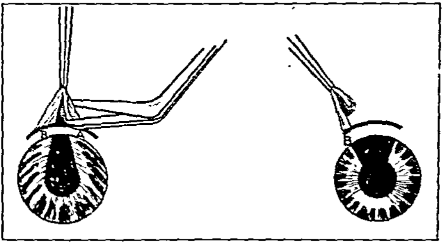


FIG. 462.—Bowman's anti-glaucoma iridectomy.

introduced into the anterior chamber, the iris engaged on its anterior surface close to the root of the iris, and the pillar stroked down very lightly by a slicing-like motion. At the same time, the entire blade can be smoothed over the cut edge of the iris to complete its release so that the pillar lies smoothly over the anterior surface of the lens. Each pillar must be handled separately. Iris prolapse, which continues after the iridectomy and which cannot be replaced, must be further resected. The operation is completed by gently stroking the lips of the incision to remove blood clots and iris pigment, and last, by smoothing the conjunctiva back from the incision line so that the conjunctiva will not dip into the wound. This also corrects any gaping [illegible] wound which may have developed.

After a [illegible] ife incision, occasionally the wound gapes slightly. If [illegible] does not correct this, one or more fine silk super- [illegible] correct it. The blepharostat is removed. [illegible] ointment placed along the palpebral fis- [illegible] ...quer dressing applied. The subsequent [illegible] the progress of the case. In general, it is

not necessary. On the other hand, one should not permit the formation of synechiæ, especially those synechiæ which occur so readily in the coloboma and at the pillars near the root of the iris.

Török[1] feels that one of the essentials of an iridectomy in glaucoma is detaching the root of the iris before making the iridectomy, that is, an iridodialysis before, rather than a detachment of the root after, the pillar is cut. In his recommendation he grasps the conjunctival flap with a forceps and pulls forward gently, making the wound gape. The root of the iris is then detached throughout the entire length of the wound with an iris spatula held in close contact with the sclera. If this is done, there is no danger of damaging the ciliary body or of losing vitreous. The iris is then withdrawn by placing the forceps parallel with the wound; one blade near the root of the iris, the other a few millimeters below. He does the iridectomy with two sweeps of the scissors and then replaces the pillars of the coloboma as is necessary.

In discussing an iridectomy for glaucoma, Jervey[2] speaks of the usual iridectomy as an anterior iridectomy. He also insists that the iris base must be separated from the adhesion covering the pectinate ligament—assuming our present ideas of the pathology and the physiology to be correct. Jervey uses a conjunctival flap, and as soon as this has been formed, enters the sclera 2.5 mm. above the limbus by an incision which he makes from 3 to 5 mm. long by repeated strokes of a small scalpel held tangentially to the cornea. A small angular iris repositor is then gently inserted through the scleral wound, between the sclera and the iris base. With forceps holding the conjunctival flap straight upward from the bulb, as soon as the point of the repositor is seen entering the anterior chamber, it is worked gently from side to side as far as the limits of the scleral opening will permit, always pulling gently forward on the repositor, so as to make it hug closely to the posterior surface of the sclera and cornea. This assures separation of the iris from adhesions over the spaces of Fontana. The repositor can be rotated on the axis of its handle and the iris can be separated from the cornea for quite a little distance beyond the limitations of the scleral opening. As soon as one is satisfied that the iris has been released, a small puncture and upward cut are made in the uveal tissue through the scleral wound. A small angular blunt hook is then passed behind the iris, hugging the iris closely so as to avoid trauma to the lens. As the hook appears in the pupillary area the sphincter is engaged and the iris withdrawn straight upward through the scleral wound and excised. Jervey states that the operator will be surprised at the size of the bunch of iris tissue withdrawn in this way, comprising as it does more iris than the ordinary anterior iridectomy.

Anti-glaucoma iridectomies, with posterior synechiæ, are usually in the nature of a peripheral iridectomy rather than one basal in type. Ordinarily one cannot withdraw the sphincter of the iris because of its adhesions to the anterior surface of the lens, and a forceful tearing of these may result in damage to the lens, if not dislocation of the lens. In such instances the technique must be modified slightly. The iris is grasped midway between the root of the iris and its adherent sphincter, withdrawn as much as is possible, and the iridectomy done from above with the blades beneath the

[1] Arch Ophth., 52, 574, 1923
[2] Am. Jour. Ophth., 11, No. 1, 8, 1928.

tips of the forceps parallel to the line of the incision and occasionally well within the anterior chamber, so that as large an iridectomy as is possible can be achieved. Ordinarily, the root of the iris cannot be reached under these circumstances; therefore, it is quite proper to combine the iridectomy with a small minimal iridodialysis. This is obtained by pulling the iris away from its root, a motion with the forceps toward the pupillary aperture, before the iris is cut.

The Complications of an Anti-glaucoma Iridectomy.—(1) Shallow anterior chamber; (2) wide dilation of the pupil; (3) corneal incision and split cornea, faulty incision; (4) ciliary body incision; (5) wounding of the iris with the cataract knife or keratome, spontaneous iris prolapse; (6) sudden loss of the aqueous; (7) incomplete iridectomy, tearing of the iris; (8) iridodialysis; (9) hæmorrhage into the anterior chamber; (10) damage to the lens; (11) dislocation of the lens; (12) rupture of zonula with vitreous prolapse; (13) inadequate postoperative toilet of the wound; (14) delayed closure of incision; (15) postoperative synechiæ; and (16) hæmorrhagic glaucoma.

Contraindications to an Iridectomy.—(1) Glaucoma absolutum; (2) acute congestive phase of secondary glaucoma; (3) buphthalmos; and (4) glaucoma; with intra-ocular neoplasms, with retinal separation, with vitreous hæmorrhage or with foreign bodies.

In general, a shallow anterior chamber makes the corneo-scleral incision rather difficult. If a keratome cannot be used, a thin-bladed cataract knife must be used preferably by puncture and counterpuncture. Even this is at times impossible, and only a single puncture achieved. If so, this single puncture must be converted into an incision of a size sufficient for the iridectomy by sharp, small, but rather stout, blunt-pointed scissors. (See also Complications to an Iridectomy for Cataract Surgery.)

A widely dilated pupil is a difficulty met with occasionally. In these instances, it is best to use a cataract knife. Further, a single puncture only should be made, and this posterior to the limbus so that the base of the incision is approximated as closely as is possible to the root of the iris. It can be made so that as the anterior chamber is opened and the aqueous gushes out through this small incision, the iris is usually prolapsed at the same time. The prolapse is permitted to remain while the incision is made sufficiently large. Burnett recommended for the completion of such an incision the use of a blunt-tipped keratome.

Faulty incisions are usually due to an incorrect position of the knife or the keratome and through an improper perforation of the cornea. If the tip of the keratome is not passed entirely through the cornea, before the handle is depressed, the keratome will split the cornea itself subsequently, and make an interlamellar incision of the cornea. Even if the anterior chamber is opened in such instances, that opening will be so far from the root of the iris that a satisfactory iridectomy cannot be obtained. Too long an incision may be obtained by introducing the keratome too far into the anterior chamber. In such instances the wound may gape subsequently. The incision with a cataract knife must not be made with too great an oblique shelf to the posterior lip of the wound. This can be prevented if one is not particularly desirous for a conjunctival flap, as would be necessary for a cataract extraction or for a Lagrange form of irido-sclerectomy. The best preventions against faulty incisions are: general anesthesia, or if

this is unwise retrobulbar injections of novocain with adrenalin added, the use of a blepharostat, firm and satisfactory fixation of the eyeball (even to the addition of a bridle suture through the superior rectus muscle), satisfactory illumination, and a slow, steady, and deliberate manipulation of either the keratome or the cataract knife. The unruly and uncoöperative patient with his painful eye is probably so often at fault that general anesthesia must be seriously considered.

When using the cataract knife, the iris seldom, if ever, falls in front of the knife because of the short incision. In spite of the shallow anterior chamber, always present when a cataract knife is being used for the incision, the complication occurs most uncommonly. This is quite likely due to the fact that the edge of the knife is well away from the pupillary aperture. If it is occurring, the knife should be withdrawn immediately and the incision completed with a pair of scissors.

A sudden loss of the aqueous with or without prolapse of the iris is a complication to be seriously considered. It may result in damage to the lens, it may be followed by choroidal hæmorrhage because of the sudden abrupt lowering of the intra-ocular pressure, dislocation of the lens may occur, and vitreous may present. Its most serious fault, however, is that because of it a small contracted residual visual field may become completely wiped out, with total blindness following. The sudden lowering of tension is probably followed by multiple minute hæmorrhages into the retina and the choroid of the macula. Occasionally, in spite of flawless technique, the withdrawal of the keratome may be followed by a spontaneous prolapse of the iris. One must proceed with the iridectomy in the same way as if no prolapse had occurred.

In the presence of posterior synechiæ it may be impossible to cut into the pupil without sufficient traction upon the iris to tear it, to damage the lens capsule itself, or even to dislocate the lens.

Curran's iridotomy for glaucoma,[1] which is an operation essentially similar to Fuchs' transfixion of the iris for glaucoma, is to be considered in these instances. Curran's peripheral iridotomy for glaucoma[2] apparently balances the pressure behind and in front of the iris, deepens the anterior chamber, and Curran himself feels that it reëstablishes drainage at the angle. For this reason O'Connor states that it is indicated only in those cases that have shallow anterior chambers and in those before the drainage spaces have been closed by adhesions to the cornea. O'Connor's technique as he modified it is as follows: (1) The Knapp knife needle must have a short (not over 5 mm.) narrow blade, so that its entire length can be manipulated in the anterior chamber. (2) It must be perfectly sharp in order to cut the iris bridge. (3) The shank must, of course, fill the puncture. (4) The eye must be fixed at two places with Elschnig forceps to prevent its rotation. (5) The puncture is started, subconjunctivally, about 2 mm. below a line tangent to the upper limbus. The blade is directed toward 90 degrees, where it picks up and transfixes a fold of iris, then continued across the anterior chamber to make a counterpuncture in the sclera, allowing a drop of aqueous to escape subconjunctivally in front of the knife point. The blade is now turned forward and withdrawn slowly, making slight pressure against the cornea. This enlarges the scleral counter-opening subcon-

[1] Elschnig: Klin. Monatsbl. f. Augenh., 70, 667, 1923.
[2] O'Connor. Am. Jour. Ophth., vol 18, No 2, February, 1935.

junctivally and cuts the iris bridge. If done properly, the hole is practically invisible, being under the scleral shelf.

It is especially essential in this operation, as in trephining, that one be on the lookout for quiet iritis and, if necessary, to use homatropin or even atropine to locate or prevent the development of subsequent synechiæ.

Horner,[1] in operating on iris bombé uses a procedure which he calls iridectomy *ab externo*. The name is apparently derived from the "sclerectomia" as suggested by Salzmann.[2] Elschnig's technique for this form of iridectomy is as follows:[3] A horizontal incision is made with scissors 6 to 8 mm. from the upper limbus to form a broad conjunctival flap, which is dissected down to the limbus as in the trephine operation. The flap is then turned down over the cornea and is grasped with smooth thumb forceps for fixation. The sclera is then scratched 1 mm. behind the limbus and parallel to it, for about 7 mm., using the tip of the keratome. For excision of tumors or cysts of the iris a longer incision is required. The incision is deepened layer by layer by scratching back and forth in the premarked groove. Slight traction on the conjunctival flap below causes the wound to gape and allows one to estimate the depth of the incision. The assistant sponges lightly after each stroke. When a perforation is made at one spot, a small prolapse of iris occurs near its root. This usually prevents outflow of aqueous. Cuts are continued to each side of the prolapse until the wound is widened to about 5 or 6 mm. The incision is enlarged with the tip of the keratome but not with scissors. Insertion of instruments into the anterior chamber is to be avoided. While aqueous may flow out during the widening of the incision, the anterior chamber does not completely empty. If, after completion of the incision, no prolapse occurs it usually signifies the presence of peripheral synechiæ. In such cases the iris must be separated from the lips of the wound by a spatula. Adhesions at the pupillary edge of the iris also may prevent prolapse. In both instances, traction on the conjunctival flap lifts the edge of the wound and allows easy insertion of iris forceps with which to grasp and pull out a suitable piece of iris. In the ordinary case, however, it is not necessary to insert any instrument into the chamber. The prolapsed iris is simply grasped with forceps, pulled forward and to the side with some force and abscised by several snips of de Wecker's scissors pressed against the sclera. At this point, the remaining aqueous flows out. Reposition of the iris is accomplished by massaging the edges of the wound with a spatula from the outside. It is seldom necessary to introduce a spatula into the wound to replace a pillar. The conjunctival flap is now stroked into place and need not be sutured. The administration of atropine is advised.

Bleeding often occurs into the anterior chamber during the operation, and it may appear later. The chamber is frequently abolished for several days and reëstablishes itself more slowly than with the classic keratome section. Graf[4] suggests that this form of iridectomy, that is iridectomy *ab externo*, should be done in all instances regardless of the presence or absence of synechiæ, in that ordinarily no instruments are introduced into the eye. As a traction is applied on the conjunctival flap, the initial iris

[1] Arch. Ophth., vol. 15, No. 1, January, 1936.
[2] Ztschr. f. Augenh., 72, 127, 1930.
[3] Klin. Monatsbl. f. Augenh., 80, 382, 1928.
[4] Ztschr. f. Augenh., July, 1931.

prolapse can be grasped, and any danger to the anterior lens capsule is definitely impossible. The author has a very high regard for the procedure.

Circumstances present naturally modify any iridectomy. Probably in secondary glaucoma with annular synechiæ, an iridotomy is sufficient for the reëstablishment of normal ocular tension. This is at least true with iris bombé. When the sphincter iridis is still intact, following an iridectomy and without synechiæ, it may be advisable to complete the iridectomy. It is a delicate procedure, however, and unless the patient is under a general anesthesia it had best remain uncut. An intact sphincter does not change the value of the operation, though it may be an indication of an iridectomy which is probably otherwise unsatisfactory. Filtration can be reestablished only if the base of the iris is released from the angle and it does not depend upon the condition of the sphincter. Synechiæ, however, develop very readily with such an intact, circulus minor. A small, blunt, and flat Tyrell hook can be passed into the anterior chamber on the flat, carried under one of the pillars of the coloboma and thence forward over the bridge of iris remaining, this bridge engaged in the hook by a slight turning of the handle of the hook and the hook and the bridge together withdrawn again on the flat. As soon as the bridge appears in the scleral incision it can be cut with the scissors. One must repeat, however, that it is a dangerous procedure. The anterior chamber is certainly lost, and lens damage will occur if the lens capsule is touched with the instrument.

A complete flat posterior synechiæ is occasionally seen accompanied by considerable atrophy of the iris. In such instances an attempted iridectomy may result in splitting the iris so that its posterior uveal surface still remains adherent to the anterior capsule of the lens. Naturally, in such instances the operation is likely valueless. An even more important factor, however, is the possibility of dislocating the lens during the withdrawal of the iris. If this occurs one must enlarge the scleral incision also, and proceed forthwith with lens extraction. In all operations upon a degenerated and atrophic iris one must be especially particular with his manipulations to prevent tearing the iris, for it will nullify the operation. If it occurs, the operation may be changed from that of a simple iridectomy to that of an iris inclusion. Iris inclusion operations are not indicated in the acute congestive phases of any type of glaucoma, but there is a greater chance for some success from an iris inclusion done under such circumstances than from the unsatisfactory iridectomy which would result if the iris is torn before the base can be cut free or detached by "arrachement."

Iridodialysis may occur in two ways. In passing the keratome, the point may become engaged in the iris and a small iridodialysis done inadvertently thereby. This is of no concern as long as the underlying lens has not been injured. A major iridodialysis may occur, however, even to complete removal of the iris during an iridectomy if the patient, whether under local or general anesthesia, makes a sudden movement of the eyeball away from the grasping forceps while the iris is being withdrawn. Occasionally it may occur when grasping or withdrawing a very painful iris. The patient, if he is under local anesthesia, is told to "look down" before the iris forceps are inserted, but he should not be told anything further after the iris is in the grasp of the forceps. Too great a prolapse may occur, the iris may be torn from the forceps, the iris stroma itself may become torn and, last but not least, a complete iridodialysis may result.

When a hæmorrhage develops into the anterior chamber before the iridectomy, it is either seepage from the incised conjunctiva or from an accidental wounding of the ciliary body or the iris. This must be removed by irrigation and as soon as the anterior chamber is free; then the iridectomy may be completed. Hæmorrhage which occurs after the iridectomy is ordinarily much less in amount, though it may be extensive. A few flecks of retained hæmorrhage, residual after the iridectomy, are of no clinical significance. They absorb rather quickly, and it is better not to carry out unnecessary irrigation and thereby risk damaging the lens capsule. Hæmorrhage adherent to the lens capsule may be present for a very long time before it is completely absorbed. A sharp or profuse hæmorrhage after the iridectomy should be irrigated before the dressing is applied and the patient dismissed from the operating room.

Damage to the lens, dislocation of the lens, and rupture of the zonula with a resulting vitreous prolapse are in the largest percentage of cases complications which should not occur. The patient has either been unruly or the operator has not exercised the greatest possible amount of care in his manipulations. Naturally, exceptions occur to this, but in spite of such instances the complication is to be regretted. A forceful closure of the lids may rupture the zonula while the iridectomy is being done, dislocate the lens at its upper pole of the lens, and permit prolapse of the vitreous. Too forceful withdrawal of the iris, in the presence of synechiæ, is another cause for lens dislocation. A faulty withdrawal of the keratome blade is probably the principal cause for damage to the anterior capsule of the lens.

Vitreous prolapse indicates a ruptured zonula. If it occurs before the iridectomy has been done, it is quite impossible to make a satisfactory iridectomy. The probability of its occurring in absolute glaucoma is one of the reasons why the operation is contraindicated in absolute glaucoma. The presence of vitreous prolapse before the iridectomy means probable failure for the operation. Vitreous prolapse which occurs after the iridectomy is even more important and grave, for an expulsive subchoroidal hæmorrhage may occur. (One sometimes wonders whether the vitreous prolapse is not the result of the hæmorrhage rather than the cause for it.) Regardless of the mechanics, it is the second of the two reasons why an iridectomy is contraindicated in absolute glaucoma. In these instances, the eye must be enucleated immediately; the period of convalescence is definitely shortened thereby, and the patient is saved weeks of pain and time which would otherwise intervene before such an eye would become completely atrophied and quiescent.

An adequate postoperative toilet of the wound may be impossible because of lack of coöperation on the part of the patient. Under ordinary circumstances a satisfactory replacement of the pillars and careful irrigation of blood clots from the anterior chamber can be carried out without difficulty. The pillars must be released, but lens damage may result from repeated irrigations, and though the operator may be satisfied with the toilet of his wound, he is faced instead with an artificially ripened cataract. Delayed closure of the incision occurs when the patient is straining, with extensive hæmorrhage into the anterior chamber, with otherwise undiagnosed superior pole lens dislocation, and when blood clot, fibrin, or conjunctiva are permitted to remain between the lips of the incision. Before the operation is completed, the lips of the incision should be stroked to be sure that this complication will not occur.

TRANSFIXION OF THE IRIS

The two procedures to be considered here are the technique as outlined by Fuchs and the technique as outlined by Curran. Both of these have been covered in the text. (See Iris Surgery, Chapter XVII.)

POSTERIOR SCLEROTOMY

Posterior sclerotomy has already been considered, in part, under the section on scleral surgery. Attention is again called to it here in that it is a sound procedure in certain forms of glaucoma. Indications, however, are rather definitely and sharply limited. The diminution in tension obtained by the procedure alone is not permanent. It is, however, a valuable means of obtaining a rapid and reasonable reduction of hypertension and in other intractable forms of glaucoma as acute hæmorrhagic glaucoma and the painful type of absolute glaucoma where enucleation has been declined. The procedure will then permit other operations which would have been *unsuccessful with the original hypertension; also it may permit the effective* absorption of miotics, formerly impossible of absorption.

ANTERIOR SCLEROTOMY

Zirm's anterior sclerotomy has definite value in the surgery of glaucoma. Stastnik performed it 101 times, with but 4 failures, for simple glaucoma. The operation consists of a number of subconjunctival cuts made parallel to and adjacent to the corneo-scleral junction, each cut partly through the sclera. The entire length of these multiple incisions is about 15 mm. A tiny opening is made in the center of the central longest cut, aqueous slowly escapes and the iris should balloon out. The incision is slightly enlarged on both sides and a broad iridectomy is performed. Zirm's opinion, concurred in by Stastnik, is that the curative effect of this anterior sclerotomy demonstrates the value of iridectomy, in that this effect lies in the interruption of a circular nervous plexus and relaxation of the blood-vessel vasomotor nerves, consequently with better circulatory conditions. Several European observers (for in their countries, anterior sclerotomy still seems to have a place) have recommended the operation as one of choice when the anterior chamber is very shallow; in that it may be done at any stage of glaucoma and in its performance the lens and Descemet's membrane cannot be injured.

Penetrating sclerotomy with diathermy has a very definite place in the treatment of absolute glaucoma. Rankin,[1] working at Wills Hospital, has in a certain number of cases had very satisfactory results in quiet absolute glaucoma by the utilization of three or four Walker quill punctures made subconjunctivally in the region of the equator, two or more in each of the four quadrants outlined by the recti. Whether or not these continue filtration as vitreous fistulæ or not, is at the present time unknown. Pathological examination of such an eye removed after death, wherein normal tension has been held, will be quite enlightening.

Vogt[2] uses and recommends very highly an anterior diathermy scleral puncture which he calls "cyclodiathermy." The punctures are made subconjunctivally over an area one-half the circumference of the globe with a

[1] Personal communication, 1939-1940.
[2] Klin. Monatsbl. f. Augenh., 103, 591-595, December, 1939

needle 0.5 mm. in length and approximately 0.18 mm. in thickness, using a current of 60 milliamperes. Approximately 100 to 150 punctures are made in an area extending 2 mm. from the limbus to 4 or 5 mm. from the limbus.

Naturally, the insertion of the recti muscles must be remembered, and avoided. This cyclodiathermy thus overlies the flat portion of the ciliary body and perhaps the anterior retina. Some vitreous loss may occur. The iris, vitreous, and retina may also be damaged and hæmorrhages appear into the anterior chamber. The possibility of a scleral slough is also to be remembered. Vogt quoted one such case in which this occurred, but the eye was successfully repaired.

The danger of the operation, naturally, lies in damage to the lens and cornea. It is for this reason that the punctures should not be made within 2 to 2 5 mm. of the limbus.

Wagner (H.) and Richner[1] reported 72 to 73 per cent recovery in 47 patients. This is an unusually high percentage, considering the fact that these all were patients who had not responded to other forms of treatment, the operation being done usually in an attempt to spare the patient an enucleation.

In discussing iridectomy and sclerotomy in its relationship to glaucoma, Dr. Otto Barkan has furnished the following description of his recently devised operation.

IRIDECTOMY AND SCLEROTOMY FOR GLAUCOMA WITH SHALLOW ANTERIOR CHAMBER

By Dr. OTTO BARKAN

SAN FRANCISCO, CALIFORNIA

Iridectomy is inadequate as an early operation in cases of the shallow chamber type in which peripheral adhesions have not yet formed and in the presence of good central vision, because it mutilates the pupil, causes glare, astigmatism and more often than not necessitates wearing glasses which were not needed before. It is furthermore exposed to the criticism of uncertainty of action since incarceration of iris, postoperative adhesions in the angle or other technical imperfections may easily occur due to the shallowness of the chamber and, in cases of high intra-ocular pressure, precipitate a malignant course.

The main technical difficulty of iridectomy in shallow chamber type of glaucoma consists in entering the knife in such a way as to obtain an adequate basal excision of the root of the iris without resultant injury to intra-ocular contents or to ultimate visual function Various methods such as posterior sclerotomy, intravenous injection of glucose, and retrobulbar injection of adrenalin have been employed to prevent too sudden reduction of tension and forward propulsion of intra-ocular contents in high tension cases. Incision "ab externo" has been recommended for the same purpose but this is inadequate, as it encourages the formation of peripheral adhesions, which increase the obstruction at the angle.

In addition to technical difficulties the lack of indications as to which cases were suitable has led to inadequacy of iridectomy. Frequently in the past iridectomy has been wrongly applied to the open angle and deep chamber type of glaucoma, or to late cases of narrow angle and shallow chamber with organic adhesions in the angle

It is evident that an operation which safely restores the physiological direction of outflow of intra-ocular fluid would be preferable to those that establish an abnormal outlet and create new and dangerous difficulties.

To be adequate an operation for shallow chamber glaucoma should widen the entrance to the angle over at least one-half or more of its circumference, preferably

[1] Ztschr. f. Augenh., 683, 1048–1053, October 28, 1939.

the upper because this is normally the narrower and is the first to close, and also because of later appearance.

It occurred to the writer[1] (Barkan) that the desired effect could be obtained with both safety and ease by deepening the anterior chamber before, during and at the end of the operation by injecting saline solution and then excising a small piece of the root of the iris at one or preferably several points along its circumference. Posterior sclerotomy facilitates the deepening in cases where the vitreous is liquid. In cases with solid vitreous or high vitreous pressure and very shallow chamber in which malignant course threatens aspiration of ½ cc. of vitreous with a syringe may be employed advantageously. Injection of the anterior chamber as the final step of the operation results in deepening and permanent restoration of the chamber thus preventing the formation of adhesions in the angle. Such excisions of the root of the iris when performed through several appropriately placed small incisions instead of through a single large one can be made to include as large an area of the circumference as desired without any untoward sequelæ. It is evident that this cannot be accomplished by means of classical total iridectomy without so large an incision and opening of the eyeball as to endanger and grossly disfigure it.

Technique.—The pupil should be miotic, the eye having been well treated with physostigmin before operation. Local preparation is the same as for any intraocular operation. The lashes of the lids should be clipped. Akinesis is secured in the usual way. Local anesthesia is obtained by means of instillation of drops of 1 per cent pontocain hydrochloride. Injection of 4 per cent novocain (without adrenalin) into the superior rectus muscle. This helps downward rotation sufficiently to dispense with a superior rectus suture. Retrobulbar injection of 1 cc solution of novocain 4 per cent with the addition of 1 drop of adrenalin 1 to 1000. Insertion of speculum.

Posterior Sclerotomy.—After turning back a small flap of conjunctiva the lower outer quadrant of the sclera is punctured with a cataract knife. In cases of liquid vitreous or in those in which the pressure is not too high posterior sclerotomy facilitates subsequent deepening of the anterior chamber by means of injection. In some cases of very high vitreous pressure or in those in which the vitreous is not fluid posterior sclerotomy does not soften the eyeball nor does it facilitate the subsequent deepening since no vitreous has been lost. In these cases in which the chamber is very shallow and malignant course threatens aspiration of ½ cc of vitreous with a Zur Nedden needle (Zur Nedden punctured the sclera directly with his needle 5 to 6 mm. posterior to the limbus. It is preferable to first make the puncture with a Graefe knife. Further experience will decide whether it is preferable to place the posterior sclerotomy 6 mm. posterior to the limbus or in the lower outer quadrant), with lumen 0.6 or 0.7, inserted towards the center of the bulbus (up to the ball of the Zur Nedden needle) may be advantageously employed. This aspiration of vitreous adequately reduces excess vitreous pressure and prevents the iris lens diaphragm from being pushed forward to block the wound and angle when the anterior chamber is evacuated. In the cases where it is indicated it prevents the possibility of a malignant course more certainly than a posterior sclerotomy alone or when combined with deepening of the chamber. It softens the eyeball but does not in itself deepen the anterior chamber appreciably. It facilitates the later deepening by injection of salt solution since the latter is not so readily accomplished without preliminary reduction in volume of vitreous. Deepening of the anterior chamber by means of an injection of physiological saline. The eye is fixated at the nasal limbus with an Elschnig forceps. The incision is made with another Graefe knife, the puncture being placed within corneal tissue about 1 mm. from the temporal sclero-corneal border in the horizontal meridian and oblique so that the inner end of the incision is situated at least half way or more to the pupil. Next a solution of fluorescein, 2 per cent, is dropped on the cornea in order to render the puncture plainly visible and the tip of a dried iodine applicator placed on the wound for a moment. A 29 bore steel needle with blunt edges (if the edges of the needle have not been dulled the tip is apt to catch in the walls of the oblique wound canal or in Descemet's membrane) and attached to a 1 cc. Luer syringe is inserted into the anterior chamber with strictest asepsis.

[1] Barkan: Glaucoma: Classification, Causes and Surgical Control (Results of Microgonioscopic Research), read before the Annual Meeting of the Association for Research in Ophthalmology, San Francisco, June 14, 1938.

Physiological saline is injected into the chamber until the iris diaphragm is pushed well back. A circular concave trough of iris is seen to form around the lens, the posterior chamber having disappeared. Deepening and injection of the anterior chamber facilitates the proper execution of the next step of the operation, namely, placement of the keratome incisions and excision of the root of the iris from underneath the limbus.

The eye is now fixated at the lower limbus with Elschnig or three prong forceps and an oblique incision with a very sharp keratome is made beginning not more than 1 millimeter scleral to the corneo-scleral border (Fig. 463). The incision thus starts just within scleral tissue. Proceeding obliquely, it almost immediately comes to lie within corneal tissue since this part of the limbus is made up mainly of corneal tissue, only the outer layer consisting of scleral fibers. Closure of the above described incision is immediate and the anterior chamber becomes reëstablished spontaneously within a short time since there is no seepage from the wound. Furthermore, the chamber may be artificially restored and deepened by means of an injection at any time during the course of or after completion of the operation.

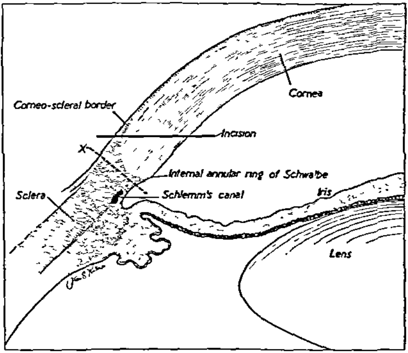


FIG 463 —Diagram to demonstrate the surgical relations of the angle of anterior chamber and limbus The chamber has been deepened Note position of valve keratome incision in this procedure. Dotted line at X shows usual direction of keratome incision for iridectomy in glaucoma (Barkan, personal communication)

The advantage of restoring, maintaining and deepening the anterior chamber is manifold. It prevents intra-ocular hemorrhage by maintaining intra-ocular pressure; it avoids incarceration of the pillars of the iris and assures a perfect mechanical result in that the patient leaves the operating room with a deep chamber, open angle and no chance of further loss of aqueous or collapse of the chamber; postoperative adhesions of the iris in the angle are thus effectively prevented. When the incision is properly placed and in spite of the inner (corneal) wound lip being considerably anterior to the entrance of the angle (the internal annular ring of Schwalbe) and to the border of Descemet's membrane, it is yet quite easy to grasp the iris near enough to its root with special iris forceps (these forceps and the needle may be obtained from the Storz Instrument Company, St. Louis, Mo.) to assure excision of the root of the iris but leaving the sphincter intact. Deepening of the chamber (posterior displacement of the iris diaphragm) makes it possible to give

the desired placement and direction to the corneal incision as also to grasp the iris near its root.

Three successive keratome incisions and peripheral iridectomies are performed in the manner described. (One excision performed in this manner is also sometimes sufficient.) It is usually found necessary to deepen the chamber with injection of saline solution after the completion of each iridectomy. The chamber should be deep and the angle open before the patient leaves the operating table

In order to prevent adhesions of iris to the inner wound lip it is sometimes necessary to use a spatula and on two occasions I (Barkan) have found it convenient to relieve an anterior thread-like incarceration of iris by means of a sweep of the end of the injection needle while it was inside the anterior chamber.

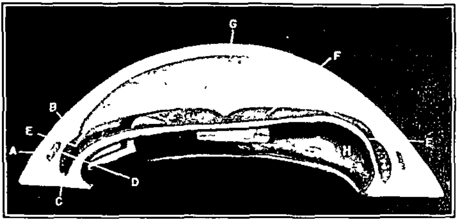


FIG. 464.—Photograph of model showing postoperative microgonioscopic appearance *A*, Schlemm's canal, *B*, internal annular ring of Schwalbe, *C*, sinus of angle, *D*, sclero-corneal trabeculum, *E*, widening of entrance to angle and posterior displacement of iris diaphragm in region of coloboma on the left, on right, beyond region of operation, only slight widening of entrance to angle; *F*, anterior surface of iris; *G*, cornea; *H*, posterior surface of iris (Barkan personal communication)

Postoperative Care.—At the completion of the operation, solution of eserine 1 per cent is instilled, and eserine ointment 1 per cent applied. The pupil should be miotic during the first week postoperative in order to keep the root of the iris out of the angle. If there is a tendency toward formation of posterior pigment adhesions it may be necessary to dilate (temporarily) the pupil with suprarenin 2 per cent or solution of adrenalin chloride 1 to 100. This should be done with due caution, however, since the chamber is shallow in this type of glaucoma and mydriasis may close the remaining angle and increase pressure. The end-result of the operation is schematically shown in Figure 464.

CYCLODIATHERMY

Some time ago Rankin, at Wills Hospital, found fair success in absolute glaucoma with transcleral diathermy in the four quadrants lying between the four recti. Naturally there is no improvement of vision, but the eyes, in the successful cases, retained stabilized tension, and were painless. Albaugh and Dunphy[1] applied a similar principle, though non-perforating, to the ciliary body as a satisfactory procedure in certain cases of glaucoma either intractable to earlier surgery, or in situations where the opening of the globe with consequent sudden reduction of the inner ocular pressure was to be avoided. Their pathological sections showed that after operation there was a definite destruction of the ciliary body. Figure 465 is the

[1] Cyclodiathermy, Arch Ophth , vol 27, No 3, March, 1942.

illustration from their article illustrating the technique. A flat electrode of the Weve type is used under local anesthesia, an application of from eight to ten seconds for each contact using 35 milliamperes of diathermy. The conjunctiva is closed with silk sutures and atropine used postoperatively. There is no doubt, from their work, that this procedure has a place in hæmorrhagic glaucoma and in certain other intractable forms of secondary glaucoma where the elevated tension cannot be controlled otherwise.

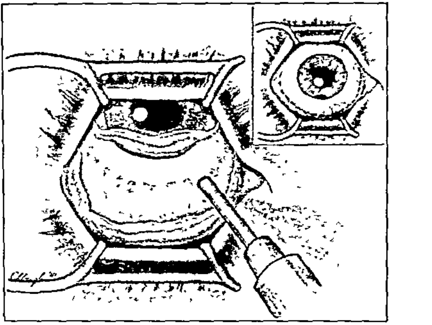


FIG. 465.—Drawing of non-perforating cyclodiathermy (Albaugh and Dunphy, courtesy of Arch Ophth.)

IRIS INCLUSION OPERATIONS, IRIDOTASIS, AND IRIDENCLEISIS

One occasionally hears the statement, relative to iris inclusion, that since iris prolapse, even though subconjunctival, is a complication usually carefully prevented, the same procedure being deliberately perpetrated clinically for therapeutic purposes seems inconsistent. The unsoundness of the apparent contradiction is proven upon the basis of actual findings. An accidental iris prolapse forms a cystoid scar, in that there is an incarceration of iris tissue present which, however, does not include the pupillary margin. Hence, the bulging of the iris is simply a diverticulum from the posterior chamber now subconjunctivally placed and without filtration. It remains irritable and is irritating to the contiguous ciliary body. The channel through which the prolapse occurs undergoes cicatricial closure and subsequent cystic degeneration develops in the incarcerated prolapsed iris tissue. It is cosmetically a blemish and surgically a fault which must be corrected. Every ophthalmologist has seen these bullous-like incarcerations following cataract extractions, as a complication of trephining, wherein the patient has forced the iris through the trephine opening, and after traumatic lacerations of the cornea. Their irritable state is evident, their lack of filtration is quite pronounced, and the cystic degeneration which occurs

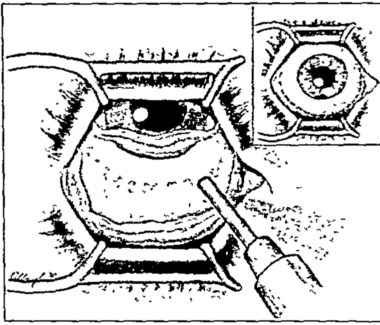
therein may proceed to such an extent that it will reach the size of a small pea and even greater. Iridotasis and iridencleisis, on the other hand are surgical procedures not complicated by concomitant trauma nor by the trauma and irritation of previously performed operations. The pupillary margin is everted and lies extra-bulbar, and the subconjunctival space is connected through the filtering cicatrix with both the anterior and the posterior chambers. The postoperative wound remains open, is constantly bathed in aqueous, the overlying bleb becomes more or less multilocular and subsequent cystic degeneration of the incarcerated iris cannot and does not occur. The free border of the sphincter iridis lies flat against the sclera and the meridional cuts, as outlined by Holth, prevent a constant traction upon the iris as the result of the incarceration. In the accidental iris prolapse first mentioned, this traction is constantly present and is undoubtedly a factor in the continued irritation. Surgically the two conditions are as dissimilar as is a stab wound through the abdominal wall unlike that of a deliberate and properly performed incision for a laparotomy.

The anesthetic demands are not as rigid as with an iridectomy, for usually one is not operating upon an inherently painful eye. The coöperation of the patient in holding the eye down during the operation is a definite assistance, and if it is necessary to operate under a general anesthetic this function must be taken over by an assistant. In spite of the advantages of local anesthesia, it may be necessary to use avertin in many cases. The disadvantages of general anesthesia are far less than those disadvantages present in operating upon an unruly and uncoöperative patient. The pre-anesthetic medication is the same, in these cases, as is that for most intra-ocular surgical operations.

After preparations of the lid and the conjunctival cul-de-sac the blepharostat is inserted and a subconjunctival injection made of a few minims of 2 per cent novocain with adrenalin or 1 per cent cocain with adrenalin, sufficient to balloon out the conjunctiva at the site of the operation. A flap is resected from above downwards to the limbus and folded down across the cornea. In forming the flap, the cuts need not be overly long, in that they should not extend too far down on the sides; in fact, the flap can be quite narrow and still be satisfactory. It should be, however, as thick and as fleshy as is possible. Under certain circumstances, the van Lint type of flap may be necessary and apparently is equally successful. It is quite essential that the incision of the conjunctiva then be absolutely limbal without leaving any cuff of conjunctiva. This is elevated and retracted by a temporarily placed suture. A retraction suture, however, should not be used in the reflected flap. It is not necessary and there is danger of tearing the flap by unnecessary or accidental traction thereon. In the case of the van Lint flap, two sutures should be placed, though untied, from the edges of the flap to contiguous conjunctiva, for instance, in the case of an iridencleisis at 12 o'clock, at 10, and at 2 o'clock; the loops of these sutures can be folded to the side.

With the reflected flap held downward with forceps, or the sliding flap held upward through the suture by an assistant, the eyeball is fixed at the contralateral point on the limbus and a small sharp keratome passed through the sclera 1 mm. behind the corneo-scleral junction. The blade is directed through the sclera at an angle as for an iridectomy, being careful that the cornea is not split with a long and unsatisfactory interlamellar

illustration from their article illustrating the technique. A flat electrode of the Weve type is used under local anesthesia, an application of from eight to ten seconds for each contact using 35 milliamperes of diathermy. The conjunctiva is closed with silk sutures and atropine used postoperatively. There is no doubt, from their work, that this procedure has a place in hæmorrhagic glaucoma and in certain other intractable forms of secondary glaucoma where the elevated tension cannot be controlled otherwise.



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incision. Figure 466, *A*, illustrates the incision with a keratome. The flap is being held down by an assistant, the eyeball is fixed below, and the keratome is introduced immediately back of the shoulder or roll of the limbus. In *B*, the flap is folded up against the flap of the keratome so that the operator can see immediately the tip of the keratome as it appears in the angle of the anterior chamber, as shown in *B*.

As soon as the tip of the keratome appears in the angle of the anterior chamber, the handle is depressed so that the plane of the cutting blade is parallel to the plane of the iris and the keratome passed into the anterior chamber for a distance sufficient to form an incision of 3 to 4 mm. In passing the keratome with this operation, it is best for the operator to stand to the right side of the patient, because the operator must see the point the moment it has penetrated the cornea. It is important also that the assistant lift the reflected conjunctival flap upward upon the blade of the keratome as soon as the tip of the keratome is engaged in the sclera itself (Fig 466, *B*).

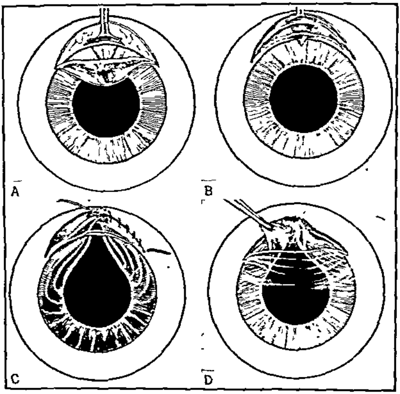

FIG 466 —Technique of iridencleisis operation. *A*, corneal incision with a flap down, *B*, completion of corneal incision with the flap folded up; *C*, completing suture of case with prolapsed tongue of iris; *D*, schematic sketch to illustrate the prolapsed tongue of iris remaining after a single meridional iridotomy, the second meridional to cut would be made to the left (reader's left) of the forceps grasping the iris.

To lessen this complication and also to control satisfactorily the length of the incision, Verhoeff[1] prefers to make his incision with a Ziegler knife needle. This can be used very satisfactorily for that purpose. One must

[1] Am. Jour. Ophth., 7, 373, 1924.

be particular, however, that the incision is cleanly cut and not feathered as a result of the frequent strokes which may be necessary: Clapp states[1] that in those cases in which the anterior chamber is practically obliterated, and especially if the pupil is widely dilated, it is almost impossible to insert a keratome without either splitting the cornea or damaging the lens. By means of a very narrow Graefe knife the anterior chamber can be entered near the iris angle, and by careful manipulation the counterpuncture made and the incision completed upward, either with an extremely large conjunctival flap or, as recommended by Bader, if the tension is very high, leaving a conjunctival bridge under which the iris can be prolapsed by means of iris forceps or a small hook.

When the incision is completed, the keratome is to be withdrawn slowly and with an oblique sliding motion so that the anterior chamber is not lost abruptly. Hæmorrhage into the anterior chamber must be removed by irrigation, and any deformity of the pupil or prolapse of the iris, no matter how slight, corrected by irrigation and with an iris spatula. Closed delicate iris forceps with a slightly longer shank than is present on the usual iris forceps are then introduced. (In most of these cases the pupil has been held in miosis and the average type of iris forceps may not have a sufficiently long curve to grasp the sphincter iridis satisfactorily.) The incision is purposely small, in that one wishes the contained iris to be held in as compact a channel as possible. An incision of 3 to 4 mm. is, however, adequate in size to permit the introduction of the iris forceps and the subsequent withdrawal of the iris. Too long an incision also may permit the subsequent postoperative return of the iris to the anterior chamber. Borthen uses a special keratome having a shoulder so that it cannot penetrate beyond a certain point. This is not an essential if one is particular as to the depth that the ordinary keratome is passed. As the iris is withdrawn, the flap must be again reflected by the assistant. As soon as the sphincter is free from the anterior chamber it should be held against the sclera firmly, but without undue pressure upon the globe. With pointed de Wecker scissors or with some modification thereof, a meridional cut is made into the iris on each side of the forceps where it grasps the iris so that the sphincter is cut in two places. Tension is prevented thereby, certainly minimized, upon the prolapsed tongue of iris remaining.

In describing the meridional cuts for the iridotomy, Holth[2] wrote as follows:

> The assistant, who stands on the opposite side of the surgeon, draws the part of the conjunctival membrane covering the subconjunctival tunnel down to the limbus corneæ; in doing this, he makes use of the blunt double hook. The surgeon uses the iris forceps with a regulating screw which widens it 2 mm.; with this instrument in his left hand he grasps the iris near the edge of the pupil and draws the iris out so far that the upper part of the pupil and, through this, the pigment epithelium on the back of the iridial tent, are seen just outside the limbal incision A presbyopic surgeon should use a "Rectavist-Lupenbrille," with a magnifying power of one and one-half for the operating distance of 16 5 centimeters. Through the extralimbal part of the pupil the surgeon inserts the one blunt blade of de Wecker's iris scissors underneath the back of the iridial tent, while the other blade rests on the front of the tent; he holds the scissors in his slightly supinated right hand when operating on either eye. He now releases the iris from the forceps (the iridial tent lies between the two blades of the scissors) and removes the iris

[1] Trans. Am. Ophth. Soc , 32, 194, 1943.
[2] Arch. Ophth., vol 4, No 6, December, 1930; Klin Monatsbl. f. Augenh , 79, 620, 1927.

forceps altogether from the field of operation. The meridional clip through the iridial tent is now made; the two sphincter angles of the narrow coloboma caused by the iridotomia retract somewhat into the anterior chamber; the double hook is removed, and the conjunctival wound is closed by a fine silk thread, which is removed the third day after operation.

The original iridotasis of Adams (1812) was later worked out by Borthen,[1] and by Harrower[2] who, Bulson states, is to be credited with having introduced iridotasis into the United States. Bulson, in a discussion on a consideration of the late operative results in glaucoma,[3] did not speak of the meridional cuts into the iris, *i. e.*, iridotasis, for his technique emphasized the incarceration of the sphincter iridis alone and did not incise the iris itself. Goldenberg[4] stated that the operated cases disclosed a distinct freedom from all symptoms, and if a glaucoma operation was indicated in the presence of a mature or immature cataract, there seemed to be no contraindication to the iridotasis technique.

After the suture is in place, the tongue of conjunctiva and the bleb should be patted lightly with the curved flat of an iris spatula to place the iris inclusion smoothly against the curve of the sclera, for it may have become disarranged somewhat while the suture was being inserted.

The postoperative dressing is rather important. Mydriatics and miotics have a relationship to iridencleisis which is less ambiguous than is that toward iridectomy. It is almost as rigid as is the relationship which they bear to corneo-scleral trephinings or to irido-sclerectomies. Atropine may be instilled at the time the postoperative dressing is applied, but no atropine is to be instilled subsequently. If synechiæ seem to be developing during the convalescence, it is better to use adrenalin and cocain or even homatropin solutions rather than atropine. The anterior chamber forms rather slowly, though not as slowly as the reformation following trephining. Hence, synechiæ are not as likely to develop as after trephining. Further, the coloboma forms a larger pupil than is that present with the intact sphincter of the peripheral iridotomy of a trephining. This removes the sphincter somewhat from the greatest curve of the lens and is another factor undoubtedly in the less frequent formation of postoperative synechiæ. It is doubtful whether the greater iris trauma, because of the greater amount of surgery to the iris, plays any rôle. Practically and actually, the postoperative care of an iris inclusion operation, while equally rigid in its demands, as with any form of filtration bleb surgery, seems to proceed with but few late complications.

The suture can be usually removed on the fifth day. It may be grasped at either end and withdrawn, or even better, withdrawn from the middle after picking up a loop of suture showing there. A drop or two of holocain will render this procedure quite painless. If the suture does not release readily from the conjunctiva and one is certain that no knots were included while it was being inserted, it is perfectly proper to wait a day or so, at which time it can undoubtedly be withdrawn quite readily (Fig. 466).

The eye begins to white as soon as the anterior chamber is reformed. At that time the use of miotics should be started routinely and continued throughout the entire period of convalescence. Their continued use

[1] Arch f Augenh., 68, 145, 1910-1911; Arch. Ophth , 40, 405, 1911.
[2] Arch Ophth., 47, 37, 1918; Trans Am Ophth. Soc , 13, 402, 1913; Ibid., 15, 122, 1917.
[3] Spaeth, E. B : Trans Am. Acad Ophth. and Otolaryng , 1928.
[4] Am Jour. Ophth., 5, 353, 1923.

depends upon the subsequent tension. In many of these cases, when under close observation, the miotic may be discontinued early.

Massage of the eyeball through the closed lids is important. It is to be started lightly and for a very few moments only, as soon as the eye is painless. Two periods daily of two minutes each is the average amount necessary. The massage is carried out exactly the same as one would palpate the eyeball with the fingers for estimating the ocular tension. It is not at all impossible to evacuate the entire anterior chamber through a bleb by means of this massage. Practically and histologically, three to six months intervene before the subconjunctival channel is wholly formed into a static filtering tunnel.

FIG 467.—Iridencleisis bleb six months after discharge from the hospital.

Swett[1] has presented a rather interesting substitution technique for iridencleisis which can well be used in instances where a satisfactory inclusion operation could not be carried out. This is especially so in cases of secondary glaucoma with degenerated irides and in instances wherein the tongue of iris has become detached, inadvertently and perhaps by too wide a snip of the scissors while the tongue was being formed. Swett's original technique is as follows:

A conjunctival flap is made above, but not dissected free down to, the limbus The incision into the anterior chamber is usually made with a keratome, but if the chamber is shallow a Graefe knife is used, the incision being about six millimeters in length. A moderate-sized iridectomy is then performed with de Wecker scissors and the section of tissue of the iris removed is floated out on physiological solution of sodium chloride. The small section of tissue of the iris is picked up on a repositor and inserted into the anterior chamber by a sweeping motion, it is placed in the sharp angle of the incision, where it is firmly gripped as the edges of the wound come together. The conjunctival flap is smoothed into place, and the eye is dressed. The fragment of iris is firmly held in the angle of the incision.

Swett never experienced any difficulty in this becoming dislodged. A postoperative conjunctival suture is definitely indicated.

Complications to an Iridencleisis Operation.—These may be subdivided into immediate and late. The immediate complications are rather similar, by reason of the technique, to those of an iridectomy; hence, repetition is not necessary here. The demands of the iris inclusion operation, however, do modify them in part. Especially outstanding are: (1) hæmorrhage into the anterior chamber; (2) tearing of the iris during its incarceration; and (3) slipping back of the tongue of the incarcerated iris into the anterior chamber. The late complications are: (1) delayed formation of the anterior chamber; (2) postoperative iritis and the formation of synechiæ; (3) the return of ocular hypertension; (4) cicatrization and closure of the filtration bleb; and (5) the handling of subsequent cataract changes.

The Contraindications to an Iridencleisis Operation.—By glancing at the chart on page 719 one can see that, in general, iris inclusion operations (with corneo-scleral trephining) seem to be one of the two operative pro-

[1] Arch Ophth, 5, No. 4, 634, April, 1931.

cedures which adjust themselves more or less satisfactorily to many glaucoma problems. Contraindications are any acute congestive phase of any type of glaucoma. When the response to medical treatment is successful, in the congestive phase of an acutely congestive form of glaucoma, an iris inclusion operation will replace to a very satisfactory degree an earlier anticipated iridectomy. In addition, it is much more lasting by reason of its continued filtration. An iris inclusion operation is contraindicated in cases with extensive degeneration of the iris. It is contraindicated in secondary glaucoma in the presence of iritic inflammation, in the presence of synechiæ which would prevent a satisfactory incarceration, and in those cases of iritis glaucoma with a history of repeated iritic inflammation. In general, any surgery except that of an enucleation is contraindicated in absolute glaucoma, but Holth feels that he has had good success in maintaining an eyeball by means of an iridencleisis.

Usually an iris prolapse should be replaced before one may proceed with an iris inclusion operation. Nevertheless several men plan their limbal incision deliberately, so that as soon as it is completed the iris will prolapse spontaneously. De Wecker,[1] in discussing the treatment of ocular hypertension secondary to iridocyclitis, plans very carefully, hoping to obtain such a spontaneous protrusion of the iris. He makes a large conjunctival flap down to the cornea and then a 5 mm. linear incision tangentially to the cornea. If the prolapse occurs immediately it is seized with forceps and two meridional incisions made through the sphincter. The two pillars formed by these incisions are slightly separated and incarcerated in the wound itself, rather than incarcerating the tongue which lies between the two, as with the technique of Holth and Gjessing. (See Fig. 466, *D.*)

The complication of hæmorrhage into the anterior chamber is unfortunate if it occurs after the iris inclusion. It would be most unwise to attempt irrigation of the anterior chamber then. Because of this, before the inclusion is done, the operator must be certain that all blood has been removed from the anterior chamber, and further, that there is no continued bleeding from the conjunctiva or from the edges of the wound. While the operator is prolapsing the iris, and especially while incising the iris, the assistant should keep the flap down over the cornea and hold a small, wet, pointed, cigar-shaped rolled sponge close to the bit of iris so that any hæmorrhage from here will be absorbed immediately, before it gets into the anterior chamber. Further, the bared sclera should be quite dry before the suture is placed into the conjunctiva.

A seriously degenerated iris is a contraindication to the operation because of the difficulty of incarcerating an iris with an abnormal texture. In many cases the iris is not wholly normal and demands careful manipulation to prevent tearing. If the patient should move during its incarceration, the iris will be torn. Moreover, occasionally after it is incarcerated, further damage is done to the iris while releasing the iris forceps. Darkly pigmented irides seem to shed pigment granules rather readily. This is of no clinical significance. The cuts into the iris on both sides of the closed iris forceps should be parallel one to the other; if they converge, the cuts may leave such a narrow bridge of iris stroma remaining that the tongue of iris will tear off and the operation be completely nullified. Greenwood,[2] in discussing operations for chronic glaucoma, stated that in a few cases in

[1] Arch. d'ophth., 53, 166, March, 1936.
[2] Arch. Ophth., 10, No 4, 474, October, 1933.

which iridencleisis was started, a friable iris became injured to such an extent that it was thought best to change the procedure into a modified Lagrange operation.

A slipping of the tongue into the anterior chamber occurs occasionally at the time of the operation and sometimes later. Too large a keratome incision is the most common cause for the retraction of the iris into the anterior chamber. The incision must be sufficiently large to permit the introduction of the closed iris forceps and their subsequent opening for at least 1.5 mm. so that the iris can be satisfactorily grasped, but an incision greater than this is not only unnecessary, but it is in error. If retraction occurs immediately, it may be possible to pick up the tongue of iris tissue formed with the iris forceps and again incarcerate it, but one must be very careful not to damage the lens. If it does occur, it is better to proceed with an irido-sclerectomy.

The Late Complications.—Delayed formation of the anterior chamber and the too early formation of the anterior chamber are both not uncommonly seen. The latter of the two is rather likely an indication of a continued or recurrent iritis and suggests lack of immediate postoperative filtration. Early massage to the eyeball may correct it. Synechiæ develop more commonly with its presence than otherwise. The delayed reformation of the anterior chamber is not especially distressing. Perhaps it is rather gratifying in that it does indicate continued filtration. The patient, however, should not be permitted out of bed until the anterior chamber is formed. Its outstanding clinical significance is the possibility of synechiæ, and these can be prevented usually by the alternate use of adrenalin and cocain as a mydriatic, and the subsequent closure of the pupil by miotics, tugging the iris sphincter open and shut to prevent them or to break them if already formed. In severe and intractable cases, glaucosan must be used, even to the subconjunctival injections of the dextro-rotatoric form, though the levo-glaucosan by instillation seems to be equally efficacious.

Foreign proteid therapy following iridencleisis has, it seems, been frequently beneficial. Certainly the mild forms of iritis occasionally seen and occasionally stirred up after manifestly secondary forms of glaucoma have receded promptly with its use.

A return of hypertension is unfortunate, but not always fatal. It may occur even in the presence of a filtering bleb. There is no doubt that the tension responds to miotics better after an iris inclusion operation than before, and this, plus massage, will usually be sufficient to reëstablish normal ocular tension. If unsuccessful, subsequent surgery is necessary. In these cases with the iris prolapsed under the conjunctiva in the form of a knob-like elevation, the tension may later become elevated. Clapp[1] dissects back the conjunctiva over the iris to a point near the limbus, and excises the apex of the protrusion, after which the conjunctiva is sutured in place. In fact, Clapp says, this procedure has proved so satisfactory that he believes that in cases of congenital glaucoma it is the operation of choice, since by this method a fistulous tract is produced which is lined by the posterior surface, or pigmented layer, of the iris. This does not seem to manifest the same tendency to close as do either a trephining or other types of operation.

Cicatrization of the bleb has been seen, though in some instances while the bleb disappeared the ocular tension remained within the normal limits.

[1] Trans. Ophth. Soc., 32, 196, 1934.

This complication may occur within the first three to four postoperative months. From the histological examination of some of these cases it seems as if it is the result of the incarceration of ciliary processes into the filtration channel. Perhaps postoperative iridocyclitis is also a factor.

The handling of cataract as a complication following iris inclusion operations is not difficult. A coloboma, for the extraction, is already present, an inferior incision may be done, though it is not necessary, as with trephining, for one can complete a corneal section without passing the cataract knife through the filtering cicatrix. In general, a two-eared conjunctival flap should be formed before the corneal section, its two lobes of a generous size lying on each side of the bleb. The cataract knife, as it emerges, will leave the eye at the limbus posterior to this double dog-eared flap, but anterior to and lower than the filtering bleb. After the extraction these two flaps can be replaced with as many sutures as is necessary.

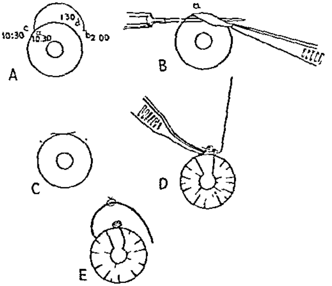

FIG 468 —Technique of iridotorsion. *A*, The position of the excentric flap is outlined as *a-b* and the incision by *c-d* Flap for *OD* would be from 10.30 o'clock to 2 o'clock, and for *OS* would be 1 30 o'clock to 10 o'clock on the nasal side. *B*, Reflection of flap for the corneal section Spot of india ink, attached to the sclera by touching with cautery point is to mark exactly the 1 mm. point from the limbus for the exit of the knife. *C*, The location for the sclerectomy, this to be done with scissors *D*, The technique of the iridotorsion. One pillar of the iris has been cut, after its prolapse by a fine hook, the opposite uncut pillar is wound, pigment layer inside, upon a fine dental probe *E* shows the suture with the cushion of wound up iris (Denig, courtesy of Arch. Ophth.)

Iridotorsion.—Denig[1] feels that his operation, iridotorsion, is the most logical and anatomically correct procedure for obtaining a fistulization with filtration by means of iris incarceration. Denig also states that eyes operated by iridotorsion are much more resistant to late infection by way of the conjunctival cul-de-sacs because of the iris cushion which closes the opening in the sclera following his operation. He states, his operation is not indicated in any case save simple non-inflammatory and chronic inflammatory, both primary glaucoma. His technique does emphasize the fact that filtration occurs very satisfactorily in incarceration channels which are lined with iris pigment.

[1] Arch. f. Ophth., 125, 156, 1930, Klin. Monatsbl. f. Augenh., 99, 1, 1937; Arch. Ophth., vol. 24, No 3, September, 1940.

CHAPTER XXIII

SURGERY OF GLAUCOMA—(Concluded)

SETON OPERATIONS

Repeatedly results are reported from their use which are certainly good. It is quite possible that circumstances may arise in which the operations are indicated.

Mayou, in 1912, presented the first of these. His procedure was the insertion of a black silk thread, 5 mm. long with a knot at one end, into the anterior chamber through a sclerotomy incision. A conjunctival flap was formed and the silk knot covered by this flap. Zorab, at the same time, presented 10 cases operated by a slightly different method, in that he used a looped silk suture also buried beneath the conjunctiva.

Herbert[1] presented the second of these operations. His procedure consisted of making a linear sclerotomy, subconjunctivally, and then fixing a small gilded metal rod or knotted thread into the wound for twenty-four hours. The rod or thread rested on the surface of the conjunctiva, depressing this into the underlying scleral wound. Elliot states, "The method does not appear to have been tried very far or to have appealed to ophthamologists." In the suture filtration operation by Clay,[2] the usual conjunctival flap is prepared under cocain or novocain adrenalin anesthesia. The technique is as follows:

The second step is done with a broad keratome. The eye is fixed in the usual manner, while the assistant holds the conjunctival flap down. The point of the keratome passes into the sclera 3 mm. back of the limbus, and as it passes into the anterior chamber, the assistant pulls the flap up over the keratome so that the operator may follow the movement of the keratome. A broad incision should be made; with the flap held up by the assistant, the operator does a broad iridectomy. The most important step in the operation is the proper placement of the sutures The assistant pulls the conjunctival flap well down. The operator, with a pair of iris forceps, lifts up the sclero-corneal lip, and with a mattress suture, using a fine cutting curved needle and No. 1 black silk, passes it through into the anterior chamber, and then it is brought out through the incision; the second needle is passed in a similar manner, 1 mm. to the side.

Row[3] described a technique carrying back to Herbert's original seton operation. He recommended it in instances of absolute glaucoma and in those eyes wherein previous operative procedures have been unsuccessful. Row's experimental work with irido-platinum wire resulted in cataract formation. He therefore devised the insertion of a loop of horse hair, this being introduced through a cyclodialysis incision, the loop being advanced through the channel until it appeared in the anterior chamber anterior to the root of the iris, that is, a supra-choroidal implantation. The two ends which protruded through the sclera were cut off so that about 2 mm. of horse hair remained exposed on the outer surface of the sclera. These were covered over by the conjunctival flap. Row found that it was necessary to introduce a Knapp iris repositor into the cyclodialysis channel to act as a

[1] Proc. Roy. Soc. Med., June, 1914

[2] Trans. Am. Acad. Ophth. and Otolaryng, p. 279, 1928.

[3] Arch. Ophth, 12, No 3, 325, 1934.

guide for the horse hair as it was fed into the channel with a pair of tissue forceps.

It seems to the writer that the disadvantage of this operation is the deliberate retention of this foreign body at the site where it is retained. It is almost as if one were playing with the possibility of sympathetic ophthalmia.

Wolfe and Blaess[1] devised a new type of seton operation in which the subconjunctival manipulation of the seton may be substituted for additional surgical treatment when secondary rises of tension occur. Their technique was abstracted in the Year Book of Eye, Ear, Nose and Throat (p. 248, 1936). Cocain instillation and a retrobulbar injection of procaine-epinephrine are used for anesthesia and for a temporary lowering of the tension. A conjunctival pocket flap is made on each side of the cornea, and under each a keratome incision is made into the anterior chamber. The seton, consisting of white braided silk, is placed in the anterior chamber by means of a lacrimal needle, and both ends are allowed to protrude under the pocket flaps. The conjunctival incisions are then closed with continuous black silk sutures which are removed on the fifth day after establishment of the conjunctival flap. If the drainage established by the seton later becomes inadequate and the tension again rises, the conjunctiva is anesthetized, and each end of the seton (thread) is seized with forceps through the conjunctiva and drawn slightly from side to side. This reopens the filtration channels and reduces the tension without again opening or incising the eye. Woods (A.), Wolfe and Blaess use the operation in cases of absolute glaucoma and in glaucoma in which previous operations had failed. They feel that their operation is a simple and easy means of controlling any secondary rise in tension which might occur without the necessity of resorting to further and more extensive surgical methods.

CORNEO-SCLERAL TREPHINING

The operation of corneo-scleral trephining, first devised by Elliot while on duty with the Colonial Indian Medical Service and published in December of 1909, was a description of his first 50 cases. It is a rather common error to consider the corneo-scleral trephining as a modification of Fergus' operation. It may be that this technique did simulate the corneo-scleral trephining, but the former of the two is essentially a scleral trephining with a cyclodialysis, opening the suprachoroidal spaces and draining the anterior chamber subconjunctivally through this channel. Elliot's operation is, as nearly as is possible a counterpart of the operation of Lagrange, making allowances for the use of a trephine instead of sclerectomy scissors; the iridectomy being added, however, not as an integral part of the operation but merely to avoid the risk of iris prolapse.

The operation may be divided into several important steps. It is quite proper that one should, in discussing this operation, use as a general outline the surgery as presented by Elliot.

The various steps for consideration are: (1) anesthesia; (2) the flap; (3) the corneal split; (4) the trephine opening; (5) the iridectomy; (6) the toilet of the wound; (7) the suture; (8) the immediate and late postoperative care.

[1] Am. Jour. Ophth., 19, No. 5, 400, 1936

Anesthesia.—Usually the operation can be done under local anesthesia. Avertin may be substituted for a nervous, restless, or apprehensive patient. The immediate preoperative ocular hypertension can be ameliorated to a great extent by a retrobulbar injection of novocain and adrenalin fifteen minutes before the operation. The higher degrees of hypertension seem to hinder the proper absorption of all drugs used for local anesthesia. This has been so frequently observed that it must be a fact. An eye in a subacute stage of congestive glaucoma is even less responsive to local anesthesia than are those cases with simple non-inflammatory types. The more recent the acute phase of congestive glaucoma, the more necessary is it to use a retrobulbar injection; not only for its anesthetic value, but also because this injection does lower the tension promptly and appreciably, though it continues for a very short time. The anesthesia is completed by the instillation of cocain and adrenalin into the cul-de-sac, and with a subconjunctival injection of 2 per cent novocain or 1 per cent cocain at the site where the flap is to be lifted. This last injection is not so important from the standpoint of ease in elevating the flap, but because of its value in rendering the sclerotomy and the subsequent iridectomy as painless as is possible. Even with the best of anesthesia, the patient frequently winces as the sclera is perforated and may complain of great pain and demonstrate this by a most distressing look of coöperation at the time when the iris prolapse and the iridotomy are done.

The Flap.[1]—The position for the trephining decides naturally the position for the flap. The usual type of flap lifted is one hinged at the cornea and dissected toward the cornea from the cul-de-sac. In certain circumstances it is wise and perhaps necessary to use a van Lint conjunctival flap instead of the one advocated by Elliot. Dupuy-Dutemps used such a flap routinely though, as Elliot states, his trephining opening is placed wholly in the sclera and is not corneo-scleral. Other finger-like flaps of conjunctiva have been recommended at various times, but they offer no advantages over the two types already discussed. Cases may arise wherein the flap has been so badly torn during the surgery that a finger-like flap of conjunctiva is advisable. If so, von Mende's technique of drawing this flap across the denuded cornea at the corneo-scleral trephine opening is logical. In such instances the frayed and perforated reflected flap, originally prepared, should be resected and discarded wholly, and the opening covered either with the finger-like flap or with a sliding flap. Elliot's form of flap is to be preferred ordinarily, but the van Lint flap should be used when indicated. These indications include those instances where repeated trephinings have been necessary; certain cases of secondary glaucoma following cataract operations where the conjunctiva is adherent to the sclera and is unusually thin and delicate; trephinings which must be done upon the limbus approaching 3 o'clock, 9 o'clock, or at 6 o'clock may be done with a van Lint flap, also in that this type of flap lends itself somewhat better to the surgery in these regions; and with some operators a sliding flap is used routinely. The writer does not agree with this practice, even though his experiences with a sliding flap have been universally satisfactory. Corneo-scleral trephining in the presence of staphylomata also should have a sliding flap. Ordinarily, the amount of dissection necessary for a sliding flap is not an

[1] See Benedict, Corneo-scleral Trephining, Trans. Sect. Ophth., Am. Med. Assn., 91, 133, 1940

advantage; still it need not nullify any of the effects of the trephining. If a reflected flap has been used and, in the subsequent dissection it has been buttonholed to such a degree that the scleral opening cannot be satisfactorily covered, it may be necessary to supplement the reflected flap by a sliding flap at the completion of the operation so that the trephine opening may be properly covered with conjunctiva.

Verhoeff's flap, as he states, has three very definite advantages: (1) it provides better permanent drainage; (2) it reduces the tendency toward the formation of a vesicular bleb; and (3) it greatly simplifies the entire operation. The late results of his flap are to hold the filtering bleb within the small region and to prevent that edema of the cornea which occurs so frequently in front of the fistula. Verhoeff's technique[1] is as follows:

With a Graefe knife the conjunctiva is severed exactly along the limbus for a distance of about 4 mm. With forceps grasping the cut margin of the conjunctiva, the latter is undermined with knife or scissors close to the sclera sufficiently far back to permit exposure of the area to be trephined and also to permit the flap readily to be pulled down well over the cornea. The corneal surface is now denuded of epithelium for a distance of about 2 mm. in front of the selected site. With one needle of a double-armed black silk suture (No. 1) a bite is taken in the cornea about 2 mm. long, parallel to and about 2 mm. from the limbus. Each needle is then passed through the conjunctival flap from beneath. The two loops of suture are then placed on the sides, out of the way. The sclera is trephined, iridectomy performed, and the operation completed by pulling the small conjunctival flap over the opening and tying the suture.

Verhoeff permits the suture to remain for at least one week, preferably longer. As a rule, the bleb ultimately retracts to the limbus, but occasionally it remains a short distance in front of it. Bentzen, up to the time of this report,[2] had been using a sliding conjunctival flap for almost three years. He feels that it is indicated for two reasons: first, most glaucoma patients being elderly, the conjunctiva is often atrophic and readily torn, and during the trephining and iridectomy the flap further may be buttonholed by the instruments; and the second reason he gave is that the reflected or sliding conjunctival flap gives a much thicker conjunctival layer overlying the trephine opening than that obtained through the classical Elliot conjunctival flap.

The technique for cutting a sliding flap has already been outlined. It is exactly the same as that described in the section on iridencleisis. The important thing relative to this flap is to be sure that it is cut free as close to the limbus as is possible, so that there is no danger of carrying epithelial cells into the trephine opening and causing thereby an implantation cyst.

In dissecting the reflected flap as outlined by Elliot (Fig. 469),[3] the conjunctiva should be grasped as far from the limbus as is possible with the patient looking strongly in the opposite direction. The conjunctiva is then retracted with the forceps toward the limbus and the incision outlined between the forceps and the cul-de-sac, as a large crescentic incision roughly parallel to the circumference of the limbus and with its two extremities terminating not at the limbus, but at points roughly concentric to it and about 6 to 8 mm. from its inner and outer edges. It is not necessary to dissect the extremities of this outlined flap entirely free from the limbus.

[1] Am. Jour. Ophth., 19, No. 1, 46, 1936.
[2] Acta ophth., 143, No. 1, 1923.
[3] See footnote, page 749.

Elliot says to do this means robbing the flap of the check ligament action of the connective tissue at the angles of the wound, and leaving this tissue in place causes the detached conjunctival flap to adhere more smoothly and firmly to its original site when released from any downward pull. As soon as the incision has been made, the dissection should be carried down to the sclera over the central area of the flap to obtain as thick a flap of conjunctiva and subconjunctival tissue as is possible. This dissection must be carried toward the extremities an amount sufficient to permit satisfactory reflection of the flap so that the limbus is cleanly exposed. Further dissection is unnecessary and is not desirable. The overlying Tenon's capsule on the sclera, which is freed, plays no rôle in the surgery.[1] As the limbus is approached, in the central third of the flap, the flap itself is carried

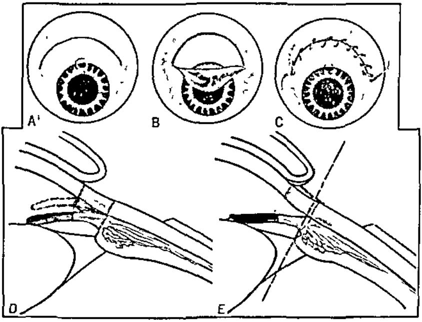

Fig. 469.—Technique of corneo-scleral trephining. *A*, incision line; *B*, corneal split showing the blue crescent lying within the corneal lamellæ, and the completed flap, *C*, continuous suture in place; *D*, tissues removed by trephining and the iridectomy now connecting the anterior and posterior chambers at an angle formerly occluded. This occlusion illustrates the reason for the usual immediate iris prolapse. Dotted in iris illustrates the usual anterior synechiæ at the angle. *E*, tissues removed by the trephining. Dotted line shows slight inclination necessary for the trephine blade.

down across the cornea until the rolled edge of the corneo-scleral junction appears. It will be necessary to bare the sclera of adherent subconjunctival tissue before this can be seen, by small snips with a pair of sharp-pointed scissors. In chronically congested cases and cases which have had repeated acute attacks, the corneo-scleral roll will be rather conspicuous. As the cornea is approached, the operator should be very careful not to perforate the flap, though the greatest danger for this occurs somewhat later. It is important that the sclera be freed of all connective tissue at the limbus before the cornea is split so that, subsequently, tags of subconjunctival tissue will not complicate the trephining itself. Elliot recommends cleaning the sclera by making a number of scraping movements over the sclera close

[1] This capsule is lifted from the sclera as the flap is dissected down its mid-sector.

above the cornea and to each side of the flap. This maneuver will "succeed in clearing the central area of loose tissue, and so provides a clean surface on which to apply the trephine blade." (Elliot.)

Splitting the Cornea.—Splitting the cornea is the next step in the operation. See *B* of Figure 469 showing a well-split cornea. It is important that the corneal lamellæ be split and not incised. Dissection with a sharp instrument, if continued too long or too far into the cornea, will simply incise it, and subsequent healing will also be complicated by cicatrization and closure of a large portion of the trephine opening. Elliot used a pair of sharp-pointed scissors. A corneal splitter, as illustrated in Figure 8, *C* is perhaps more easily used for this. The eyeball should be fixed with Elschnig fixation forceps on the sclera close to the reflected edge of the flap. Fixation by means of conjunctiva is a mistake. The eyeball cannot be held firmly, and the conjunctiva will tear and complicate the subsequent closure. While the operator holds the eyeball firmly, through this fixation, an assistant can keep the conjunctival flap folded down away from the limbus and cornea by means of conjunctival forceps, by a suture in the flap, or by a tightly wound cotton applicator moistened in saline. At the same time, the common distressing hæmorrhage which arises from the exit point of a superior-anterior ciliary vein can be controlled by the slight pressure of a second cotton wound applicator moistened in a 1 to 1000 adrenalin solution. If this is unsuccessful one must touch the bleeding vessel, lightly, with actual cautery. It is essential that hæmostasis be complete before the cornea is split, and even more important, it must be absolutely complete before the trephine opening is made. Splitting of the corneal lamellæ is started in the sclera and in the sulcus between the cornea and the sclera. Short tangential strokes are made with the points of the closed scissors or with a sharp corneal dissector, with McReynolds' corneal wedge, or with some type of corneal knife. As soon as a definite ledge has been lifted, the author exchanges this sharp-pointed splitter for one with the point and the edges blunted. The split is accomplished by an oblique-like stroke downward, at a tangent to the limbus, slightly backward, and with a circular sweeping motion. At this time it is most important that the flap be kept away from the point of the splitter so that it will not be buttonholed. (See section on Late Complications.) It is also necessary that hæmostasis be wholly controlled so that the operator can see what he is doing. As the split progresses, a blue corneal crescent appears (Fig. 469, *B*). It is unnecessary to split the cornea to a degree greater than 1 mm., that is, so that half of a 2 mm. trephining opening will lie in the cornea while the other half lies in the sclera. Too anterior an opening will bring the trephine opening too far from the anterior chamber angle, and the subsequent iridectomy will not be purely basal, especially if it is only a peripheral iridotomy. Also, the opening may be followed by long-standing edema of the cornea. Elliot states that the operator may be certain of a satisfactory corneal split when he observes that the line of reflection of the flap is no longer curved at the corneal margin, but now crosses the blue crescent in a straight line, as a bow string crosses a bow. His suggestion is valuable, for in many eyes the cornea shows up rather poorly, especially when considerable congestion has preceded the operation. In such instances, it is oftentimes difficult to get a split of 1 mm., and the operator may have to be satisfied with a corneal crescent of a lesser degree. The purpose of this split

is to obtain a corneo-scleral position for the trephine opening and at the same time, to obtain as thick a corneal-conjunctival flap over the trephine opening as it is possible to obtain. This step of the operation is not difficult, but it must be done carefully. Figure 469, *B*, shows the position of the corneal crescent and its proportionate size, even though diagrammatic. The reasons the trephine opening must lie for at least one-half of its distance in the cornea are evident; one must evade the region of the ciliary body; the corneo-scleral opening should lie at such a place that it will not be subsequently plugged with ciliary processes, for the farther back the trephine opening is in the sclera, the more likely will this occur; the more anterior the trephine opening, the less likelihood is there of iris prolapse and of subsequent adhesions of the iris to the posterior surface of the cornea at or about the trephine opening; and the more posterior the incision, the more likely will impaction occur, the return of pathological intra-ocular tension, the rupture of the zonula and vitreous prolapse, and the possibility of lens damage. The ideal position, as said, is to have one-half of the opening in the cornea and one-half in the sclera.[1] There is more danger connected with too great a posterior rather than with too far an anterior displacement. The latter of the two errors is difficult to achieve, the former of the two mistakes may occur so readily that one must be constantly on guard against it. Figure 469, *D*, shows the position of the disk under the split lamellæ of the cornea and at the corneo-scleral junction line lying halfway on each side of the limbus, also with the position of the underlying peripheral iridotomy indicated. This portion for iris resection would be that shaded part of the iris prolapsing as soon as the corneo-scleral perforation occurs.

Trephining.—The trephining itself may be done with any one of a number of instruments. There are several different models on the market all of which have been undoubtedly satisfactory to the operators who originated them. Some of them are clock driven and others depend upon manual manipulation. Practically the simplest trephine is the best as Elliot's modification of the Bowman trephine. A 1.5 or 2 mm. blade is necessary, preferably the larger of the two. There seems to be no good reason why a trephine blade should be truncated or cone-shaped though many have been made this way following Stephenson's original model Other trephines have been made with a shoulder rather similar to that on a cranial trephine so that it is impossible for the operator to advance the blade more than a certain fixed distance. Some have been built with a slot above the cutting edge so that it can be more readily cleaned. All of these, it is true, have various interesting qualities but none of them are essential. A 2 mm. sharp straight trephine of Elliot's simple model is adequate and if technical mistakes are committed with this, similar ones, and perhaps equally serious, will be committed with other types. The only danger with a straight trephine is the possibility of a too sudden and too deep penetration into the eyeball by the inexperienced operator. Von Hippel's blade with its protecting adjustable shoulder may be seriously considered but with this type of clock driven trephine one must always feel concerned relative to the sterility of the instrument.

Klainguti[2] made and used an electric motor trephine which the writer

[1] See footnote, page 749.
[2] Ztschr. f. Augenh., 45, 349, 1921.

has felt, from the time he first saw it, up to the present, has the fewest objections connected with a mechanical trephine. The instrument consists of three parts, an electric motor on a separate adjustable support, the tube from this and the hand piece. This hand piece can be handled as readily as a cataract knife, and the trephining itself is done with clear unobstructed view and without pressure. The blade has a circular groove 2 mm. from the crown for adjusting the depth to which it can penetrate. The number of revolutions varies from 1500 to 6000 though Klainguti usually uses it at an average speed of 2000 revolutions. The advantages of this machine are the light weight of the hand piece, its mobility, and the certainty with which it can be sterilized. Vogt's electric trephine as well as certain others (Taylor, Reber, etc.,) are instruments quite similar and undoubtedly have similar advantages.

In each case, before the blade of Elliot's model of the Bowman trephine is sterilized, it should be tested on a kid drum so that the operator can be assured of its being sufficiently sharp. More complications can occur from a dull trephine, even with a good operator, than from a sharp trephine under any circumstances. The trephine handle is taken between the thumb and index finger and placed behind the corneal split, holding it slightly up and anteriorly, and inclined slightly away from the true radius of the eye, that is, tipped a bit forward toward the cornea. The dotted line on Figure 469, *E* illustrates this. With the handle held free and not supported on the forehead, the blade is turned rapidly to and fro in this inclined position. The weight of the trephine is sufficient for cutting and the operator should not put any further pressure upon the sclera. The handle which Elliot recommends is one weighing 9.7 grams. The motion which is imparted to the trephine is a rolling motion between the thumb and the index finger, back and forth. Any one point on the edge of the trephine blade will, with each turn, make a rotation of nearly 360 degrees. Its purpose is to assure a disk which will be cut free in its corneal content though still hinged on the scleral side, and by this prevent a free detachment of the disk with perhaps its loss into the anterior chamber. After two or three tentative turns the trephine may be lifted from the position where it was cutting, the position of the cut inspected, hæmostasis again carried out, adequate fixation of the eyeball assured, and then the trephine replaced in the same circular groove where it was started. The free movement of the hand (Fig. 470) unsupported, makes it possible to tell when the corneo-scleral lamellæ have been perforated. The patient may wince because of the bit of pain which occurs at that time. If the operator is in doubt as to the distance he has traversed, it is always permissible and perhaps wise to lift

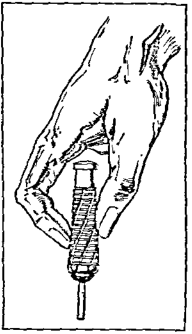

FIG 470 —Correct position for holding a trephine chuck.

the trephine and inspect the wound and see how far he has progressed. Several men have called attention to a sign which almost invariably appears when the trephine has perforated the corneo-scleral junction. It depends upon the loss of some aqueous, and this may be unnoticed by the operator. Axenfeld described it as a slight forward and upward movement of the iris, as the anterior chamber is opened and the pupil becomes rather abruptly pear-shaped with its apex upward. This prolapse of aqueous and pear-shaped deformity of the pupil are common even when the trephine opening is not wholly completed. Several slotted trephines have been presented, from time to time. It was hoped that presentation of the fluid through the slot above the cutting edge would warn the operator of the perforation. The author has tried such trephines, and they have never worked out satisfactorily. One can tell only by the feel of the resistance, by the behavior of the patient, and if in doubt, by the repeated inspection of the incision. A sharp trephine is essential, though one must not forget that all scleræ have different densities, resistances, and even different thicknesses. Also it is easier to penetrate too deeply into an eye with grave hypertension than into one with the lesser degrees of hypertension. If, in the cut, one finds a very tiny prolapse of the iris with a major portion of the sclera disk still uncut, the trephine has been inclined too far forward, and it will be necessary to straighten it up to a line more nearly parallel to a radius of the globe more on the hinged part of the disk. This is permissible even after a fair sized knuckle of iris has presented, though it should not be done if any of the aqueous has been lost. If the disk has been cut free and is still in view, the iridectomy should be done immediately. If it has been cut free and the disk is not in view, search for it should be delayed until after the iridectomy has been done. If the disk still remains hinged to the scleral edge of the cut, it is best to permit it to remain there while the iridectomy is being done and to cut it free thereafter with pointed sharp scissors. The de Wecker iris scissors and most other forms of iris scissors are too delicate to cut the disk free satisfactorily. Stouter scissors must be used. Occasionally, in cutting free a partly attached disk, one will be aware of deep scleral lamellæ still present and intact. It would be well if these could be picked up with iris forceps and removed. It is important, however, that no damage be done to the underlying ciliary body, for it is during such manipulations that a traumatic cyclitis is set up. If this is done after the iridectomy, one is also inviting rupture of the hyaloid and vitreous prolapse. If the operator sees, before the iridectomy, that the resection of the disk is not going to be satisfactory it is better to correct this with the trephine blade before the iridectomy (see above). In those cases where search for a lost disk has been properly postponed until after the iridectomy, one should first look into the barrel of the trephine if it is not therein and not lying upon the tissues contiguous to the wound. A careful inspection must be made of the anterior chamber angle, to be sure it has not dropped therein. This has happened several times to the writer. In all instances but two, the disk was picked out of the anterior chamber angle without any damage whatsoever. In one case, however, it had migrated slightly to the side and was seen there after the iridectomy; in the other instances the disk was found in that same position several days after the operation. In neither instance were there any untoward results

from this, and certainly it was the wiser plan to allow it to remain rather than to risk other complications by fishing for it.

Iridectomy or Iridotomy.—Under ordinary circumstances, the iris prolapses spontaneously as the trephine penetrates the eye. There are several different ways of doing the iridectomy. In many instances a simple cut close to its base, as an iridotomy, with blunt pointed de Wecker scissors in a circumferential line will be sufficient. The aqueous gushes out, and the iris bleb collapses and falls back into the trephine opening. This is the usual sequence of events in simple non-inflammatory glaucoma. In those cases which have been congestive, however, the iris should be grasped in forceps and a peripheral iridectomy made of that prolapsed portion also using the de Wecker scissors. Ordinarily, the iris should not be drawn up into the wound; in fact it is unwise to put any traction at all upon it. This is certain with cases of secondary glaucoma wherein synechiæ are present. In such instances there may be no prolapse of the iris whatsoever. If the anterior chamber is promptly lost, with other than these cases, it might also be permissible to close the wound without attempting an iridectomy. When the iris is bound down by synechiæ, it is generally not only as unnecessary to attempt an iridectomy, for these will prevent subsequent prolapse, as it is inadvisable because of possible lens damage. If the iris can be picked up, however, failing prolapse and in the absence of synechiæ, and brought to the corneo-scleral level so that even a small iridotomy is possible, the success of the operation is more nearly certain. There is the possibility of damaging the underlying lens or the suspensory ligament or even the vitreous. Elliot feels that, barring the possibility of a later prolapse, quite as good results occur without an iridectomy as with one; therefore, when such a contingency arises (and fortunately it seldom occurs) one must, as Elliot states, "decide which is the lesser of the two evils." If one has delayed very long with the iridectomy after the initial prolapse, it may slip back into the anterior chamber. Each individual instance must be met separately, and if later complications occur, as a subsequent prolapse, or the return of tension, reoperation will be necessary. The return of the iris to the anterior chamber before the iridectomy is unfortunate. It is for this reason that the operator is urged to proceed with the iridectomy immediately after the prolapse of the iris and not to fuss around with the disk. Attention to this is logical later. In operating on cases with a dilated pupil, the iris prolapse which occurs may be so great that even the sphincter iridis is included in the prolapse. These especially need an *iridotomy* without grasping the iris with forceps. If one should do an *iridectomy* without forceps and scissors, an incomplete iridectomy may result with a thin bridge of iris remaining at the sphincter. Such a condition is quite distressing because it is almost certain that this thin thread of sphincter will adhere to the lens in permanent posterior synechiæ.

Many do a complete iridectomy routinely. They feel that the quiet iritis and resulting synechiæ are minimized decidedly by this. Further, that even if an iritis should occur in these instances, and the sphincter iridis become bound down by synechiæ, the coloboma of the iridectomy will remain open because of the greater distances there between the edges of the coloboma and the receding convexity of the lens. As stated under the section on iridencleisis, one must weigh all factors in an operation, its faults and possible complications no less than its virtues and benefits. This

applies here especially. With a completely prolapsed iris, it may be wise to do a complete iridectomy. In the case of an unruly patient or one who can be expected to be uncoöperative after the operation, a complete iridectomy will certainly prevent the subsequent prolapse of the iris. Cases of secondary glaucoma with a spontaneous prolapse of the iris, complete, should naturally have a complete iridectomy. Cases of primary glaucoma with lens changes making certain an early cataract extraction should also be operated with a complete iridectomy. Trephining in the presence of an Argyll-Robertson pupil should also have a complete iridectomy because of the poor response such eyes give to mydriatics. *One must not lose sight* of the important thing relative to the iridectomy, that is, its purpose is to prevent an iris plug from closing the trephine opening and to furnish a channel for more free flow of aqueous from the posterior to the anterior chamber. The iridectomy has nothing to do with opening a filtrating angle. The operation presupposes that the anterior chamber angle is permanently occluded, and that the subconjunctival filtration resulting from the trephine will replace this. Practically, many men have reported that some of their finest results occurred in cases where a peripheral circumferential iridotomy was alone done. Other men of equal eminence in ophthalmic surgery routinely do a complete iridectomy and quite properly feel that they need make no apologies for this procedure. Considering all cases it seems that late quiet or secondary iritis is most common in those cases which formerly were congestive. For this reason a complete iridectomy is to be seriously considered in all cases which were congestive in type. Elliot's own words[1] are rather conclusive:

> No one who has had an experience of the quiet iritis which so often follows operations for glaucoma by any and every method can doubt the great value of the power thus put into our hands by the performance of a complete iridectomy in congestive cases.

The Toilet of the Wound and the Suture.—As soon as the iridectomy or iridotomy has been completed, the disk should be resected. Elliot recommends the resection of this at the same time the iridectomy is done. In certain instances this can be done, but in general, the author would rather make it two separate procedures, one for the iridectomy and one for the disk. The edge of the disk is to be grasped by fairly stout forceps, lifted free from the hole, and the posterior hinge cut as closely to the sclera as is possible. The nozzle of a gravity flow anterior chamber irrigator is then placed at the posterior lip of the trephining opening and the iris washed back into the anterior chamber. At the same time, any blood which may have flowed into the anterior chamber can be removed. Vigorous irrigation, however, is not necessary. A few tags of hæmorrhage if left in the anterior chamber will absorb quite rapidly, and lens damage can occur from an over zealous irrigation. The surgeon should be careful that the trephine opening is free from tags of iris tissue which can be seen floating in the stream from the irrigator. Pigment and blood clot should be also washed therefrom.

The flap is then folded back against the sclera, smoothed with an iris spatula, and its base carefully inspected to be sure that it has not been buttonholed during the operation. In the greatest proportion of cases, the

[1] Elliot: A Treatise on Glaucoma, 2d ed., London, Oxford Medical Publications, 1922.

buttonholing of the flap occurs at that time of the trephining itself. A running suture is then started at one extremity of the conjunctival incision and this closed in a water-tight manner. Figure 469, *C*, shows the position of the suture, the peripheral iridotomy, and the replaced pupil. A buttonhole in the flap must be carefully closed—usually by a second purse-string suture about the break in the flap—pulling the hole at the same time to the side. Before the speculum is removed, the flap should be patted down once more with an iris spatula and smoothed out, for it is not at all uncommon to find a bubble of air beneath it. A portion of atropine ointment should be instilled and a Barraquer dressing applied. Under ordinary circumstances a monocular dressing is sufficient; also, as it is rather commonly necessary to continue some form of medication in the other eye, this could not be done if a binocular dressing was applied.

The first postoperative dressing should be twenty-four hours later. At that time, the cul-de-sac is to be irrigated, the pupil carefully inspected, and additional atropine instilled. In a satisfactory trephining the anterior chamber ought not to reform before the third to the fifth day. If reformation occurs before this, something is at fault and it must be corrected if possible. (See Complications, page 759.) The pupil ordinarily will dilate very poorly as long as the anterior chamber is unformed; therefore it is quite necessary to continue cycloplegics and daily inspection of the eye to forestall the development of any synechiæ. If these are occurring, adrenalin packs should be used immediately, even before the formation of the anterior chamber. Glaucosan may be necessary, especially with the dark irides. The suture may be withdrawn between the fifth and the seventh day and hot compresses added to the atropinization to hasten the recession of the postoperative reaction. As soon as the suture is cut, the patient is able to be up and about. Certainly, however, the patient should not be out of bed before the anterior chamber is reformed. The patient may be discharged from the hospital as soon as the anterior chamber is formed, the suture removed, the pupil nicely dilated, and the operative reaction receding. After the anterior chamber is formed it is easier to combat the development of synechiæ. Occasionally, it is necessary to use alternatingly miotics and midriatics to relax and then to tear developing synechiæ. Foreign proteid therapy may be of some assistance in these cases. Certainly, the atropinization must be continued until the eye is white, until there is no further relucency of the aqueous beam in the anterior chamber, and until the surgeon is certain that there is no further danger of synechiæ. With filtration present one need not be concerned about an increase in tension due to the atropinization. If this occurs, it is rather certain that the operation would have been unsuccessful, and perhaps it is well to obtain this information at as early a date as is possible.

Complications.—The complications which can and do occur may be divided into two groups, the immediate and the late.

The immediate complications are: (1) anterior chamber collapse but without decrease in the ocular tension; (2) buttonholing and tearing the flap; (3) failure of iris to prolapse; (4) inability to replace the iris; (5) hæmorrhage, superficial and intra-ocular; (6) loss of vitreous; and (7) damage to the lens.

The late complications are: (1) closure of trephine opening by iris or ciliary processes; (2) late iris prolapse; (3) return of hypertension; (4)

development of synechiæ; (5) delay in the formation of the anterior chamber; (6) cataract; (7) loss of the bleb and of filtration; (8) hypotony; (9) late infections; and (10) detachment of the choroid.

Immediate Complications.—Occasionally, the anterior chamber empties abruptly, but when palpating the eye either with the finger or when indenting the cornea with an iris spatula, one is aware of the fact that the ocular tension has not dropped. In these instances it is likely that the iris was adherent rather far forward in the anterior chamber angle, and the corneoscleral opening has become abruptly plugged With the exception of these instances, if uveal tissue is dragged into the wound, it is due to the operator's own faulty manipulations which have resulted in the temporary incarceration of uveal tissue. The iris should be washed back into the anterior chamber; if this is not possible it may be necessary to introduce a narrow iris spatula into the wound directed anteriorly toward the pupil and even backward toward the ciliary body, to release the adherent uvea.

Buttonholing or tearing the flap is unfortunate. It has, however, occurred to every operator of any great experience. If the tear occurs before the trephine opening has been cut, it is possible to offset this opening to one side or the other from the position originally planned for it. The tiny laceration in the flap can be subsequently closed with a single silk suture which will not be near to the trephine opening. If a small rent is found in the flap close to the trephine opening, after this has been completed, it may be possible in a large percentage of instances to displace this tear to one side by a purse-string suture about the tear, and traction on the suture and tear by tying the ends of the suture a bit to one side of the position of the opening. In this way, 1 or 2 mm. of displacement needed can be gained If the tears, however, are extensive and lying at the base, the flap should be resected and the trephine opening covered either with some type of a finger conjunctival pedicle flap or with a sliding flap, according to van Lint's technique, or to some other recommended for this purpose. A modification of Beard's hinged flap is very satisfactory, see Figure 471. One must be certain that the conjunctiva has been removed wholly from the limbus when this type of flap is utilized.

A failure of the iris to prolapse always occurs in secondary glaucoma when multiple posterior synechiæ are present. Remembering the purpose of the iridectomy in the operation, it is best to complete the toilet of the wound and to suture the flap forthwith. In the absence of synechiæ and failing a spontaneous prolapse of the iris, one may attempt to grasp the iris in the trephine opening and perform a minimum iridotomy if he is reasonably certain that the lens will not be damaged thereby, and that he will not drag unwanted uveal tissue into the trephine opening. This same applies to a premature recession of the prolapsed iris into the anterior chamber before the surgeon has had an opportunity to perform the iridectomy or an iridotomy, as the case may be.

Inability to replace the iris after the iridectomy by irrigation compels the surgeon to do a complete iridectomy of the portion which continues in prolapse. This complication may be the only indication at the time of an intra-ocular hæmorrhage; also following such an extensive iridectomy the zonula may become ruptured and vitreous prolapse through the trephine opening.

Superficial hæmorrhage should be staunched and minimized by adrenalin

and by cotton applications upon an emissary ciliary vein where it appears on the sclera. This is especially so with the rather common vein at 12 o'clock on the sclera lying 6 to 8 mm. from the limbus. At times hæmorrhage from this and other superficial ciliary veins may be so persistent and so annoying that it is necessary to cauterize the veins to stop the hæmorrhage. The procedure is relatively simple. An ordinary squint hook is heated red hot in an alcohol flame, and the vein touched with this cautery tip 6 to 8 mm. from the limbus, away from the site of corneal splitting. As the iridectomy is usually done *ab externo*, there should be no hæmorrhage from this into the anterior chamber. That which develops may be subsequently removed by irrigation as the iris is being returned to the anterior chamber. Irrigation of the anterior chamber should continue until the

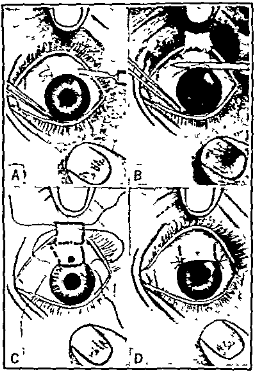

FIG. 471.—Beard's hinged flap for trephining. That in *B*, Beard states, is no longer used, the flap now being completed as in *A*. (Courtesy of P. Blakiston's Son & Co.)

pupil is round. If hæmorrhage is still present at this time, it is best to permit it to remain rather than to continue the irrigation. An intra-ocular hæmorrhage, subchoroidal, occasionally occurs in arteriosclerotics due undoubtedly to the sudden upset in the previously established ratio between intra-ocular pressure and intra-vascular blood-pressure. It is a most unfortunate complication, and once it occurs usually nothing can be done except to proceed with an enucleation. The eye is inevitably lost and the convalescence period is much shortened by the enucleation. The complication is so serious and the end result so tragic, that it seems permissible to try anything which offers the possibility of useful vision after the operation. In two instances, both definitely cases of *subchoroidal hæmorrhage*, and not the so-called choroidal detachment, usable vision was conserved following

multiple stab sclerotomies with the tip of a cataract knife. In one instance, the hæmorrhage had not broken through the zonule to the external surface, *i. e.*, through the zonule and through the trephining opening, to the external surface. This was perhaps the saving factor. In one of the two, the subchoroidal hæmorrhage was immediately drained, as it was developing. The elevation of the retina, as a result of the hæmorrhage, was observed in the pupillary aperture prior to the completion of the operation. In the second of these two cases, the retinal elevation was discovered at the end of the operation. In this instance, (a one-eyed individual) the subchoroidal hæmorrhage was drained by multiple posterior sclerotomy punctures three days later. In this instance, the blood was very watery and quite black, quite different from the brighter blood, which readily clotted, in the first of these two cases. Combating this complication is at best a matter of prophylaxis, *i. e.*, preparing the patient preoperatively by sedatives, through the use of vasodilators, and by as much preoperative lowering of the ocular hypertension as is possible and logical.

The loss of vitreous means a rupture of the zonula and may also be an indication of lens damage. A bleb of vitreous in the trephine opening is a most serious deterrent to satisfactory drainage from the anterior chamber. The complication usually occurs either from straining on the part of the patient, unfortunate roughness while closing the flap with a suture, or because the trephining opening was made too far posteriorly on the limbus. A shallow anterior chamber and deformity of the angle predispose to a rupture of the zonula and subsequent vitreous prolapse The complication is always serious, especially when it occurs at the time of the operation. If it should appear before the iris has been returned to the anterior chamber and if it is possible to change the peripheral iridotomy into a complete iridectomy, this must be done, and the vitreous which has presented cut off. The flap suture is carried out in the same manner, but a mild pressure dressing should be applied to the eye, and in these instances the first dressing should not be done until forty-eight hours have intervened.

Too often one hears the statement that a trephining operation predisposes to the formation of cataract. Careful clinical observation does not confirm the statement. Excluding those cases wherein damage has been done to the lens as a result of faulty manipulations during the operation, it is doubtful if a trephining operation with an uneventful convalescence modifies in any way the development of lens opacities, or even the increase of preëxisting lens opacities. It is quite likely, however, that the formation of synechiæ hastens opacification in the case of an immature cataracta complicata. In such instances, and with this type of developing cataract, one cannot be sure that the glaucoma is not secondary in nature and contingent upon the cataract present before the operation. Cataract and glaucoma both appear most commonly in individuals of an age wherein early lens changes have their greatest incidence. The manipulations necessary to a trephining operation, if carried out properly, are not in any way the cause of advancing lens changes.

The Late Complications.—Late iris prolapse and the closure of the trephine opening by iris or by the ciliary processes is an occasional complication. It occurs with secondary as well as with primary glaucoma; perhaps with the latter it is a bit more common, also, though the reasons are not clear,

following congestive glaucoma. Troncoso and Reese[1] examined with a gonioscope 29 cases following corneo-scleral trephining, from 22 patients. The complications grossly were: incarcerated ciliary processes in 12 instances; incarcerated iris in 7 instances; incarceration of both in 1 instance; exudations in the angle with attachments to the ciliary body, to the sclera or to both, 6 instances; marked postoperative iritis with posterior synechiæ in 7 instances; and normal appearance in 3 instances. With a gonioscope these observers found three main complications, *i. e.*, incarceration of the ciliary processes in the operative opening, incarceration of the iris in the sclera, and exudations adherent to the ciliary body and the sclera. Some of their cases were studied, histologically as well, to confirm their gonioscope observations. If the condition arises, it will usually appear the third or fourth day after the operation though it has appeared as late as the tenth day. In an instance wherein the second eye was operated at that time, the distress to the patient, her squeezing, and her general restlessness undoubtedly were the cause for the prolapse. A similar sequence of affairs may occur when it is necessary to operate one eye after the other with the least possible delay between the two operations. If the average iris prolapse is not corrected, it will nullify the operation, it will most likely increase in size even to a marked degree, and not only will the operation be nullified, but added thereto will be the factor of constant irritation from the incarcerated non-filtering iris. Ciliary processes which prolapse into the bleb will ruin the operation, and there is nothing which can be done surgically to correct this. Usually the complication is undiagnosed except by histopathological examination. It is one of the two main reasons why corneoscleral trephining is not especially satisfactory in absolute glaucoma. (The other is because of the high degree of iris and ciliary body atrophy and the complete loss of the anterior chamber.) In this condition the changes which occur in the sclera and the cornea at the site of the ciliary body, make ciliary process prolapse quite possible. A return of tension with signs of cyclitic irritation should make one suspicious of the complication. Trephining ought to be repeated immediately and at this time with a complete iridectomy. If it is possible to clean out the former trephine bleb by actual cauterization, a cicatrix will close this off and at the same time correct the source of the ciliary insult. A tiny early iris prolapse may be correctable by actual cautery. In general, however, it is necessary to lift a sliding conjunctival flap from above the bleb and to resect the bleb with its overlying conjunctiva with a broad sharp keratome. In such cases the suture should be placed first for the sliding conjunctival flap. The sclera must then be cleaned about the protruding staphyloma and sutures passed from the edges of the sclera and sclero-corneal junction, each from above to below the staphyloma. The loops of these sutures are moved to the side, the incarcerated iris and the conjunctiva resected, and the two scleral corneoscleral sutures immediately tied, closing this limbal defect. Figure 472, *A*, shows the sutures *a*, *a'*, *b*, *b'*, for the conjunctival flap and *c*, *c'*, and *d*, *d'*, for closing the wide gap at the limbus from the long standing iris prolapse. The entire cystoid cicatrix may now be removed, close to the sclera, by passing a sharp broad keratome through its base. As soon as it has been removed, *c*, *c'*, and *d*, *d'*, should be tied. If the patient remains quiet at this time, no vitreous will be lost. A central wound remains as

[1] Am. Jour. Ophth., 18, No 2, February, 1935

the original trephine opening. The conjunctival flap sutures are then tied. The pillars of the incarcerated iris may *not* be released at the root, as sketched in *B*, but a large complete iridectomy will be present in spite of this. Cases operated in this manner may mean the conservation of an eye which otherwise would be ultimately lost. Frequently, a second trephining will be necessary as well, but the prolapse must be repaired.

The return of hypertension in a trephined eye demands careful analysis. If it is due to one of the complications already mentioned, these should be corrected. If it is not a return of hypertension, *per se*, but simply an incomplete lowering of the hypertension formerly present, further trephining must be done. One may consider a cyclodialysis as the secondary operation but only in the absence of congestion and without signs of iritic or cyclitic irritation. A moderate return of hypertension may be controlled at times with varying miotics. This is one of the reasons why, in simple non-inflammatory glaucoma, it is ideal to keep the sphincter intact for the effect of miosis is definitely enhanced thereby. The sectioned sphincter of a complete iridectomy does not respond to the miotics as does an uncut

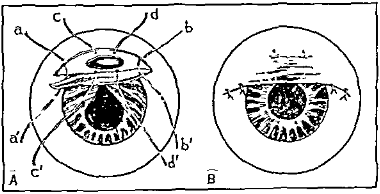

FIG. 472.—Repair of a post-trephining cystoid cicatrix (See text)

sphincter. A return of hypertension, with signs of irritation, should have a complete iridectomy with the secondary operations. One may also consider seriously an iris incarceration operation as a satisfactory supplemental procedure.

The importance of closing a button-holed flap rests here—in that it may be the cause of a secondary glaucoma due to the downgrowth of epithelium through the trephine opening.

The development of synechiæ is unfortunate. Their presence is an indication of irritation and at the same time is the cause of continued irritation. A vicious circle is established which cannot be well controlled. Frequently, the surgeon is quite helpless in preventing this. It may be due to neglect on the part of the patient, and at other times even with the best of efforts by the ophthalmologist, these adhesions occur. Knowing this as a fact, one appreciates why a complete iridectomy must be done in cases trephined in the presence of low grades of congestion or with a history behind them of formerly present congestive or iritic phases. The vigorous use of mydriatics and of cycloplegics to tolerance, the use of foreign proteid therapy, and in some instances alternation between strong miotics and strong cycloplegics

as with eserin or amino-glaucosan (the strongest miotic we have) followed by dextro- or levo-rotatoric glaucosan are the means of combating this.

According to Zentmayer's experience[1] the post-trephining complications most commonly are either a frank iritis, or an insidiously persistent iritis occurring with proliferation of pigment and with fibrinous deposits disseminated over the anterior capsule of the lens and visible in the pupillary area and in the coloboma. Zentmayer has also spoken of various rapid but transient, though marked, changes which occur in the refraction of the eye following trephining. This occurrence is not rare and it is always difficult to correct or adjust. Zentmayer thought that the changes might be due to alterations in the rate of filtration through the filtrating scar bringing about a change in the position of the lens. According to Cowan, however, the differences in the refraction thus noted are too great to be accounted for in this way.

An early delay in the formation of the anterior chamber is logical and is desirable. When this delay continues, even with an absolute non-formation of the anterior chamber, one may be certain that complete posterior synechiæ are forming not only at the sphincter iridis but also upon the entire posterior surface of the iris. The lens lies closer to the cornea than is normal, there is an increase in the fluid content of the vitreous body; and these cases are not all accompanied by hypertension; it is seen almost as commonly with gross hypotension. The complication is serious and nothing can be done for it surgically; it is indicative of a low-grade cyclitis and generalized uveitis. The lens becomes cataractous and even with a later successful extraction the eye may degenerate to phthisis bulbi.

Cataract.—The question of cataract following trephining operations, not as an accompaniment or coincident with, but as a complication of the operation, has already been covered. Naturally, in that section, reference was made largely to the effects of cataract from trauma to the lens, in that the discussion is properly included under those immediate complications which occur incident to the surgery. In so far as the late development of cataract is concerned (excluding those cases accompanied by iritic or cyclitic irritation), it is doubtful whether the operation itself plays any rôle in precipitating cataract formation or in hastening the development of lens changes which existed prior to the surgery.

The loss of the filtering cicatrix, that is, the disappearance of the bleb, is seen at times, especially when the trephining operation has been done in younger individuals. It is rather interesting that many of those cases continue with normal tension or with a tension rather readily controlled by miotics in spite of the absence of filtration. It almost seems as if the results of the surgery and the duration of the bleb were sufficient to carry the patient over a period of gross hypertension into a second period of normal ocular tension or of tension fairly well controlled. The same thing has been seen in older patients, even in senile patients, and in those instances usually additional surgery was necessary. A cyclodialysis may hold them within normal tension. It is best, however, to repeat the trephining operation or to do an iris inclusion operation. Relative to the disappearance of the bleb, Knapp[2] had one patient who was under constant supervision, in whom the trephine opening closed after eleven years, with a return of glaucoma,

[1] Am. Jour. Ophth., vol. 14, No. 7, July, 1931.
[2] Arch. Ophth., 10, No. 3, 300, September, 1933.

requiring another trephining. The prognosis after secondary trephining is less hopeful than that after the primary operation, and the more dissection that is done, especially in scar tissue, the less likely is filtration to result.

The question of hypotonia is rather interesting and is controversial. It does occur at times *after all filtering operations. Extreme hypotonia has* been seen to such a severe degree that the eyeball was actually indented by the overlying upper lid and demanded a cylinder of very high degree for the resulting astigmatism. In spite of this, the eye in question has continued without degeneration for years. The example is quoted not as a representative of the cases, however, because uveitis with degeneration and with late retinal separation has been seen and reported by various other observers. There is nothing much that can be done for the condition. Its presence is rather likely a further proof of the many varied and unknown causes for glaucoma. Similar states of hypotonia, even to the same degree, are seen occasionally after the cataract extraction and especially after the late repair of an iris prolapse following cataract operation. In these instances, there is no manifest site of filtration and still the hypotonia is present and remains unchanged for years, without showing any demonstrable ophthalmoscopic or slit lamp signs of degeneration. One dare not make light of hypotonia, but neither is it a sign that ultimately degeneration of the eyeball will occur.

Reoperations for hypotonia are not usually advisable for two reasons In the first place, they are seldom necessary, in that the severity of the hypotonia does not demand it; secondly, it is always a serious thing to reoperate a case wherein the intra-ocular vascular system has become adjusted to hypotension. A new and secondary glaucoma may become established, far more serious than the condition for which the original operation was done. When the surgeon is convinced that the hypotonia is so marked that it must be corrected, Wheeler's recommendation can be carried out. A crescent of corneal epithelium is removed from the upper part of the cornea with a curette including the limbus. The conjunctiva is then dissected free from the limbus in its upper half, including the conjunctiva of the filtering bleb. This flap is then drawn down across the denuded cornea and sutured there. It should adhere firmly at the place denuded, but not otherwise. Further, this adhesion will remain permanently.

The operation is satisfactory not only following the usual operations for glaucoma, but also in the occasional leaky wounds following cataract extraction and penetrating wounds at the limbus.

Barkan (H.)[1] recommended the use of a small type of thermophore to the bleb in cases of post-trephining hypotonia. A temperature of 150° to 180° F. is to be used, the bleb being touched in various places for from five to ten seconds. Barkan states that after several treatments, a dense flatter bleb occurs, due probably to thickening of the conjunctiva, and the intra-ocular pressure returns to normal.

The bête noire of trephining operations is the possibility of late infections. It seems to occur in the best of controlled cases, though rather likely its highest incidence occurs in that group of careless, slovenly, and oftentimes untidy patients seen so commonly in the clinics. Immediate post-

[1] Am. Jour. Ophth., 23, 692, June, 1940.

operative infections are fortunately quite uncommon. Walker[1] feels that some of our cases of postoperative uveitis following trephining in primary simple glaucoma cases may be due to dirt, oil, and other foreign substances inside the barrel of the trephine drawn into the eye by suction as the trephine blade penetrates at the corneo-scleral junction. For this reason, he devised a new drill with double windows and polished so that the barrel or lumen of the blade can be easily and thoroughly cleaned.

Cattaneo[2] had the opportunity of studying a case microscopically wherein a pneumococcus infection developed eighteen years after trephining for secondary glaucoma. The anterior chamber was filled with pus, and a ring abscess developed in the cornea. The pneumococcus was found in both smears and in cultures of the aspirated aqueous, and sections of the enucleated eye showed the same organism present in the vitreous. A study of the serial sections of the enucleated eye seemed to indicate that the route of infections is from the conjunctiva over the trephine opening to the corneal stroma, and from there it extends into the intra-ocular contents of the globe. Eerola[3] made a study of the late results in 5016 trephining operations. The individual reports upon which this survey was made showed marked variations, the percentages varying from none to 13.6 per cent. One hundred infections were reported from this very large group. In his same survey, 954 cases of iris inclusion operations were analyzed, and these showed only a 0.3 to 0.4 per cent incidence of late infections. Considering all of the filtration operations, it is interesting that the incidence of late infections is highest with trephining and lowest with iris inclusion operations. The microscopic anatomy of a satisfactory multilocular trephine bleb does not suggest any reason for this. In some cases, acute nasal pathology and chronic nasal accessory sinus pathology seem to be a factor. Others start with a simple unrelated muco-purulent conjunctivitis. At least one instance has been seen which was rather likely pyemic in nature, in that it was intercurrent or accompanied acutely suppurating external hæmorrhoids. The presence or the development of an acute suppurative conjunctivitis, in the presence of a trephine bleb, calls for urgent and drastic treatment to a degree which would hardly be demanded for a conjunctivitis of the same severity present in a case without the filtering cicatrix. Irrigations of bactericidal solutions, foreign proteid therapy, the silver salts, subconjunctival injections of Pregyl's iodine solution, and of 1 to 5000 cyanide of mercury solution are all indicated. The intra-ocular infection when it occurs shows an early relucency of the aqueous beam in the anterior chamber, circumcorneal injection about the bleb and pus early in the anterior chamber. An eyeball can be saved, even at this period, by heroic treatment, but its integrity is already seriously imperiled. At this stage, cyanide of mercury injections should be done daily and even twice in twenty-four hours; 8 to 12 minims to be injected subconjunctivally about the bleb. Foreign proteid therapy is absolutely essential. Salicylates should be given by rectum in starch water in 40 grain doses daily, and hot compresses, atropinization and dionin used locally. Other forms of supportative treatment are to be added as the occasion and

[1] Arch. Ophth., vol. 5, 1931; Eye, Ear, Nose and Throat Year Book, Chicago Year Book Publishers, p. 208, 1931.
[2] Ann. di ottal. e clin. ocul., 63, 481, 1935.
[3] Acta ophth., 12, 137, 1934.

the opportunity presents. Paracentesis of the anterior chamber was done in one instance but without success. Brown's recent work with intravenous typhoid vaccine therapy and with subsequent anterior chamber paracenteses, as in uveitis, may be tried here. This therapy has certainly assisted in cases of extensive post-traumatic corneal ulceration with hypopyon. In cases severely infected (Staphylococcus aureus and the streptococcus) early diagnosis and vigorous treatment are important factors in this complication.

Detachment of the choroid occurs rather frequently after intra-ocular operations. Perhaps it is not as frequent after trephining as it is after cataract surgery, but one can see it often if frequent fundus observations are made upon a large number of patients. The complication has some clinical significance however. The cases usually recover spontaneously, even without special attention. As a matter of fact, Elliot[1] feels that keeping the patient lying down does not appear to have a beneficial effect but rather the reverse. He gives them permission to walk about, taking a usual part in the activities of their life, and oftentimes at the next subsequent examination, the separation which was responsible for the visual shadow of which they complained, has wholly disappeared. The author has had one instance wherein the condition continued for several months after the surgery. There is, no doubt, a connection between this and delayed formation of the anterior chamber.

GONIOTOMY

By DR. OTTO BARKAN
SAN FRANCISCO, CALIF

This is one of the latest operations to be presented for simple non-inflammatory glaucoma. The operation was devised by Dr. Otto Barkan of San Francisco, and his technique, prepared by him for publication in this work is as follows. His results permit him to feel that the operation is a sound surgical procedure in indicated cases, as covered below.

This operation is indicated in a certain type of case only, namely, that type which according to the writer's classification constitutes a pathological anatomic entity which he has called Type I Chronic Glaucoma. This is characterized by an open angle and normal depth of the anterior chamber. It includes the clinical group of what is commonly known as chronic simple or non-congestive glaucoma, but in addition covers all cases with deep anterior chamber and open angle even though they be congested. It does not include those cases with shallow chamber and narrow angle that run a non-congestive course for many years and clinically appear similar and are often confused with typical chronic simple glaucoma. The procedure is especially gratifying when used as an early operation. It will be found effective also in certain cases of secondary glaucoma in which the increased intra-ocular pressure is likewise due to a block of the sclero-corneal trabeculum. It is less effective and may even be contraindicated in certain rare instances of Type I which show a high degree of vasomotor instability and tendency toward vascular decompensation. A preliminary paracentesis may here be indicated or it may be better to operate primarily by cyclodialysis or trephine.

Goniotomy or opening of Schlemm's canal under direct vision is an operation for the relief of that form of chronic glaucoma which is characterized by an open angle and normal depth of the anterior chamber.

The success of the operation depends upon two essential factors: (1) the proper selection of suitable cases by a preoperative biomicroscopic examination of the angle of the anterior chamber; (2) the use of a specially made contact glass, the

[1] Am. Jour. Ophth., 14, No 10, 1002, 1931.

prismatic action of which provides a magnified picture of the inside of the angle of the anterior chamber so that the surgeon is able, under direct vision, to guide his knife from the temporal limbus across the anterior chamber until it strikes the trabeculum on the opposite side. A similar approach to the angle was used by De Vincentiis in 1892 but his procedure was a blind one since it was impossible to see where the knife was going. Moreover, in the absence of a biomicroscopic (gonioscopic) method, it was impossible to determine which cases were suitable. The operation was later abandoned.

Preliminary Procedures.—The surgical contact glass[1] (Fig. 473) should be tried on the patient's eye previous to the day of operation in order to insure its adaptability to the individual case. The standard model will be found to be satisfactory for most cases but occasionally an exceptionally narrow palpebral fissure demands the use of a smaller model. The lids are separated with a speculum, or by means of lid sutures in cases of a narrow palpebral fissure. Canthotomy should be avoided for a trace of blood in the conjunctival sac is apt to disturb visibility by mingling with the fluid between cornea and contact glass. As direct vision is the essence of this procedure the thought of maintaining visibility must always remain foremost in the surgeon's mind. Everything should be ready before local anesthesia with pontocaine is started. Anesthesia should not be prolonged beyond the few minutes that are necessary to induce it. Once the glass is applied, the steps of the operation should follow in rapid succession in order to avoid disturbance of visibility through haze of the corneal epithelium that might develop, formation of Descemet's folds (which may occur in low tension eyes after prolonged contact with the glass) or through entrance of air bubbles or blood between contact glass and cornea.

Fig. 473.—Barkan's surgical contact glass. (Personal communication.)

Technique of Operation.—The pupil should be miotic, the eye having been well eserinized before operation. Ointment should not be used, in order to avoid the formation of an oily film on the glass. Akinesis is performed in the usual way. The height of the operating table and of the eye of the patient is so adjusted that the surgeon who stands at the side of the patient's head may conveniently transfer his gaze from the limbus to above the temporal edge of the contact glass and to the anterior chamber by means of slight movement of his head or body. If the surgeon prefers to sit on a stool, its height must be adjusted relative to the eye of the patient so that the surgeon may transfer his gaze by means of a slight movement of his head. Local anesthesia is instilled by means of 1 per cent pontocaine. An applicator saturated with 1 per cent pontocaine may advantageously be held on the nasal limbus for five seconds. A drop of adrenalin solution 1 to 1000 given with the last drop of pontocaine increases the corneal luster. Immediately following the last drop, the eye is fixed with a forceps and the surgical contact glass applied in the following manner. In the case of the right eye both the patient's face and his gaze are rotated to his left. In the case of the left eye the directions are reversed. The conjunctival sac having been freed of mucus or débris that may disturb the visibility the surgeon grasps the limbus at ten o'clock with a small Elschnig forceps, with lock, held in his left hand. The forceps having been locked it is permitted to hang from the limbus. It will be found that fixation is best done before application of the glass rather than after. If, however, the surgeon prefers to apply the glass first, then in order to prevent entrance of air through dimpling of the sclera he must exert a little extra pressure upon the glass with an applicator held in his right hand while grasping the limbus with the forceps in his left. The surgical contact glass having been placed on the eye, a solution of physiological saline is injected under the temporal edge of the glass by means of a 1 cc. Luer syringe with a small curved cannula.

Still maintaining the head in this position the patient is directed to rotate his gaze slowly from the left straight upward. The eye with the contact glass upon it is now in a position of abduction relative to the head and looks straight at the ceiling.

The assistant, who stands behind the head, keeps the glass in position by means of a double pronged probe (bident, Fig. 474) which is held in the right hand without

[1] The surgical contact glass is now available from Zeiss & Co.

exerting undue pressure, and in such a manner as to leave a crescent of the temporal limbus exposed. Such pressure as there is must be in *the direction of the optic axis of the globe* in order to avoid entrance of air under the glass. As soon as fixation is established and the glass applied, care must be taken to avoid pressure with the forceps. Traction rather than pressure should be exerted. The surgeon then (1) dries the temporal limbus with the tip of an applicator, (2) applies iodine at the intended point of puncture with an applicator, (3) punctures at this point (just scleral to the corneo-scleral border) with the goniotomy knife. A second assistant

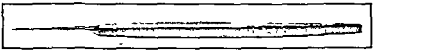

Fig. 474.—Barkan's bident probe

or nurse has meanwhile guided the narrow beam of a hand lamp[1] from across the bridge of the patient's nose to transilluminate the nasal portion of the limbus and the corresponding region of the angle of the anterior chamber. The surgeon who stands in a comfortable position at the side of the patient's head, the table having been previously adjusted to the proper height, guides the knife (Fig. 475)[2] across the chamber and into the angle between its lower and nasal third in the right eye and between its upper and nasal third in the left eye by direct vision through the glass. When the blade reaches the magnified angle its point is inserted into that portion of the trabeculum which covers Schlemm's canal and the incision is continued counter clockwise for several millimeters along this line (about one-quarter of the circumference). For the right eye *the surgeon stands to the right of and* behind the patient's head; for the left eye he stands at the patient's left shoulder. If the incision appears insufficient either in extent or depth, the knife may be rotated on its axis and the incision repeated in the reverse direction. The knife is then quickly removed without loss of aqueous, care being taken to avoid enlarging the puncture wound at the limbus by pressing slightly against the back of the blade during removal. There may be a slight amount of bleeding into the anterior chamber from the intra-scleral plexus along the line of incision but this is absorbed within a few hours.

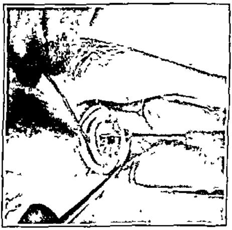

Fig. 475.—Goniotomy (Barkan) showing the knife crossing the anterior chamber (Personal communication.)

The knife must, in traversing the chamber, always cross the optic axis. The diameter of the arc that it describes after having engaged the trabeculum will then be greater than the diameter of the circumference of the limbus and thus the point of the knife remains engaged during the incision. If the knife does not cross the optic axis the opposite holds true, with the result that the point of the blade in describing a smaller arc than that of the limbus soon becomes disengaged from it, resulting in too small an incision.

Due, apparently, to the varying topographic relations of the angle and of Schlemm's canal, one cannot always be certain of opening the canal. That this may be accomplished with a fair degree of certainty and exactitude is shown by the results of postoperative bio-microscopic examination which usually shows a single straight dehiscent slit of the trabeculum over Schlemm's canal associated

[1] An improved focal illuminating lamp designed for this purpose will be available in the near future. The goniotomy knife can be obtained from Mueller & Co.

[2] Figure 475 illustrates an earlier model of the contact glass and bident than are now being used.

with normalization of intra-ocular pressure. What appears to be the glistening white inner lining of the outer wall of Schlemm's canal is visible through this longitudinal bisection of its inner wall. The sclero-corneal trabeculum may either be bisected or torn off constituting what may be called a trabeculotomy or trabeculectomy respectively. Judging by experiences it would appear that an incision to the extent of at least one-quarter circumference is required for a permanently successful outcome. A too small incision is only partially effective and it may also be that it is more apt to close in time, although one cannot be certain of this at present.

Magnification is obtained by wearing a binocular head loup of desired strength. A five diopter head loup when combined with the refractive power of contact lens and eye gives a total linear magnification of about 6 ×. In selected cases where higher magnification is desired the operation may be performed with a corneal microscope attached to the surgeon's head by means of a helmet. With this microsurgical technique 20 × magnification may be obtained.

An assistant or nurse who stands on the opposite side of patient's head directs the spot light of a hand lamp at the nasal limbus, transilluminating it. While the incision is being made the spot light is made to follow the point of the knife which is visible to the assistant through the sclera as it moves along slitting the trabeculum. The surgeon can further direct the movement of the light by word of mouth. A second assistant or nurse stands beside the first one towards the foot end of the patient and directs the light from a second hand lamp onto the eye for purposes of general illumination. This light can be removed or used at will during the procedure. It also serves as a reserve in case the first light should become obscured or get out of order. Thus constant illumination of the angle of the chamber is assured during the operation.

Patients are customarily hospitalized for two to three days, both eyes being occluded the first twenty-four hours. The pupil of the operated eye should be kept miotic with eserine for three weeks following the operation, in order to prevent the root of the iris being washed against or becoming adherent to the incision.

The essence of the procedure is its complete safety. There have been no complications or injurious sequelæ observed in any cases operated upon to date. This makes it especially adapted to early operation which is the greatest need in the surgery of glaucoma today.

Handmann's sclerectomy, which he spoke of as a scleral corneotomy,[1] has good permanent value and is to be considered as the minimal possible surgery when such circumstances present themselves. In the 30 cases which he presented, with his original operation, 6 were reported as very good, 13 as good, and 10 additional as satisfactory. An incision is made at the upper limbus, almost as in a cataract extraction except that a small bridge of limbus and of conjunctiva is left undivided at the center, that is, the points of puncture and counterpuncture are lengthened but not connected. With a pair of blunt scissors two radial cuts are made in the corner at the central point of the two corneo-scleral incisions so that tiny triangles of cornea are excised with a 1 to 1.5 mm. base at the peripheral incision. Eleven cases had been under observation for more than two years and 17 for more than ten years. In rather more than one-half of the cases, adhesions developed between the root of the iris and the corneal wound.

Herbert's sclerotomy is a somewhat more rational procedure, is equally easy to do, and obviates iris prolapse and the iris adhesions of Handmann's technique. Lister, in his simplification and description of Herbert's flap sclerectomy,[2] uses a broad needle or a narrow keratome to puncture the conjunctiva 6 mm. from the limbus; the blade of the keratome is slid under the conjunctiva and is made to enter the sclera a millimeter or so behind

[1] Klin. Monatsbl. f. Augenh., 73, 39, 1924.

[2] Berens: The Eye and Its Diseases, Philadelphia, W. B. Saunders Company, p. 1125, 1936.

the limbus. It is passed from here into the anterior chamber, making an opening 3 to 4 mm. wide. Having entered the anterior chamber, a vertical incision is made at each end of the primary incision by turning the knife so that its edge is forward, then cutting to the margin of the cornea, care being taken not to section the conjunctiva. In this way a small quadrilateral flap or trap-door of sclera is formed. If the iris prolapses, a buttonhole iridectomy is done on the prolapse.

Some surgeons prefer raising a small flap of conjunctiva to facilitate the introduction of the knife into the sclera and to assist in making the vertical incisions. Lister says the importance of gentle massage every day after the operation cannot be too greatly stressed. This serves to keep the trap-door open, thus starting drainage into the subconjunctival tissue at the earliest possible moment. The conjunctival flap is closed with a suture as is customary.

Lagrange stated that as a permanent opening was made, passing from the anterior chamber angle into the subconjunctival space, the perichoroidal space was also opened by his operation. It is quite unlikely that this occurs. Shortly after Lagrange presented his original technique, various other similar sclerectomy operations were advanced. Argyll-Robertson presented one, the scleral trephining of Fergus already mentioned, and Herbert's wedge operation was still a third. Scleral trephining is no longer practiced, and the same thing applies in general to the wedge operation as advised by Herbert. In this, two sclerotic cuts were made through the sclera, outlining a wedge for removal. Elliot describes Herbert's various operations quite in detail, the wedge resection, his small flap sclerotomy, and the triple flap sclerotomy. They are of interest historically, no doubt, but in general they are not recommended by the writer. Other procedures less difficult to do and more certain in their effects are recommended instead. The procedures to be described herein are the original technique of Lagrange, Holth's modification of it with punch forceps, the pocket flap sclerectomy of Spratt, and the more recent irido-corneo-sclerectomy of Berens.

IRIDO-SCLERECTOMY

The sclerectomy of Lagrange, which probably has been the basic operation for all scleral operations wherein a filtering cicatrix is formed, was first presented by him in 1906.[1] "Iridectomie et sclerectomie combinées dans le traitement du glaucome chronique. Procédé nouveau pour l'établissement de la cicatrice filtrante." It is rather likely that his sclerectomy was based upon the anterior or internal sclerotomies of de Wecker and of de Vincentiis. The procedure for these is not included herein. Their incisions through the sclera and through the anterior chamber are of no permanent value. As Meller says, "the wound margins of these are so well adapted that primary healing occurs." In 1894, de Wecker[2] added an iridodialysis to his sclerotomy incision, but it is doubtful whether this had any additional value.

The Lagrange Irido-sclerectomy (or, as he speaks of it, sclerecto-iridectomy).—Figure 476, *A*, *B*, *C*, *D*, and *E*, illustrates the procedure. Local anesthesia is usually satisfactory in that the operation should not be done

[1] Soc. franc. d'ophtalm., May, 1906, A Combination of Iridectomy With Sclerectomy for the Treatment of Chronic Glaucoma. A New Procedure to Establish a Filtering Cicatrix.

[2] Ann. d'oculist., 112, 261, 1894.

upon acutely congested eyes. The pupil should be kept contracted, as much as is possible, with eserin before the operation and while the cocain drops are being instilled. Just before the operation is started, 3 drops of 1 to 1000 adrenalin are most desirable to prevent bleeding from the conjunctival flap. A short narrow von Graefe knife with a thick back is passed through the anterior chamber, the puncture at the outer side being 1 mm. from the limbus, with a counterpuncture at the opposite limbus matching this. The knife enters close to 10 o'clock and emerges close to 2 o'clock on the limbus, in the case of the right eye when operating from above, or at opposite points on the left eye when operating this from below. The knife is carried upwards and slightly backwards in such a manner that

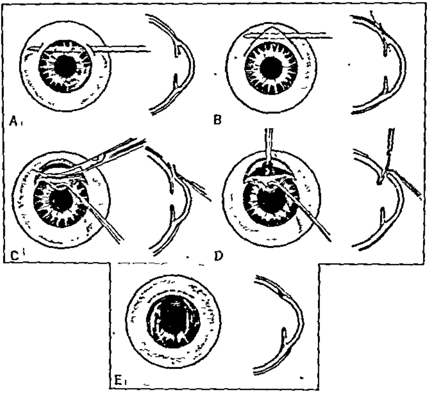

FIG. 476 —Technique of Lagrange irido-sclerectomy. *A*, corneal section; *B*, beveling of sclera; *C*, resection of scleral lip with scissors (or punch); *D*, iridectomy; *E*, completed result.

the sclera is beveled or cut obliquely. The section is completed with a tongue-shaped conjunctival flap of from 2 to 8 mm. in height. If the anterior chamber is allowed to empty itself very slowly under the conjunctiva before the scleral section is completed, the fluid forms a subconjunctival bleb, and this facilitates decidedly the formation of the conjunctival flap itself. By this procedure a scleral incision is formed from 5 to 7 mm. in length with a definite ledge of sclera at the anterior lip of the wound. When the conjunctival flap is grasped with forceps and pulled down over the cornea, this tongue or shelf of sclera is plainly visible. While the conjunctival flap is held reflected, sharp, curved, but small scissors are used to remove this scleral shelf. The conjunctival flap is held down over the cornea by an assistant, the operator fixes the eyeball with one hand.

and with the other removes a biconvex or cigar-shaped section of the sclera from this ledge. It will be, from apex to apex, 3 to 5 mm. in length and from 1.5 to 2 mm. in width, at its widest part. To obtain a scleral shelf of adequate size, *the knife must emerge from the sclera 2 to 3 mm. from the* limbus in an oblique backward course, as it leaves the anterior chamber and begins the formation of the conjunctival flap. That portion which is resected is not corneal, as Elliot says, but is largely scleral. The conjunctiva at the exact corneo-scleral junction line is not disturbed nor dissected free from the limbus. As soon as this sclerectomy has been done, the iris is grasped with iris forceps, prolapsed, and a basal iridectomy carefully done. The iris scissors should be held tangentially to the cornea, and the iris which has been withdrawn removed with two or three snips of the iris scissors. Originally the iridectomy was not considered as an essential part of the operation. It has the same value and purpose as with a corneo-scleral trephining. Subsequent iris prolapse or incarceration is prevented, and these would nullify the filtration desired. The iris is replaced by *anterior chamber irrigation or with an iris spatula, and the conjunctival* flap sutured with a water-tight suture, the same as for a corneo-scleral trephining.

The postoperative care is not unlike that of corneo-scleral trephining except that massage should be started in these cases as soon as the anterior chamber begins to form. Atropinization is necessary here also The site of the sclerectomy must be free from any tags of iris or of uveal tissue, for the procedure is not of itself an iris inclusion operation. The scleral opening will remain patent without incarceration of these. It is so large, as compared with the opening of a trephining, that one must do a complete iridectomy. A peripheral iridotomy or an incomplete iridectomy has been tried several times, but the procedures were not satisfactory. The extensive opening of the anterior chamber and the slow reformation of the anterior chamber demand the complete iridectomy. The suture can be removed on the fifth or sixth day, depending upon the rapidity with which the anterior chamber forms. As soon as this has reformed and the suture been removed, the patient may be out of bed.

The sclerectomy, as done by Holth[1] with his punch forceps, is not unlike the Lagrange procedure. The von Grafe knife is passed as before, and a scleral flap from 2 to 2.5 mm. in width is formed with a conjunctival flap extending 6 to 8 mm. from the limbus. The punch is held, according to his latest technique, with the 1 mm. wide blade of the punch forceps on the flat, parallel with the sclera in a tangential direction, introduced at the nasal angle of the wound, 3 mm. into the anterior chamber. The handle is lowered until it forms an angle of 150 degrees with the plane of the iris. The piece of sclera is now excised by closing the punch forceps; it should be 3 mm. long and the anterior edge should be placed rather more than 1 mm. from the limbus. Holth recommends a complete iridectomy if the iris prolapses or tends to prolapse. In the case of a non-congestive secondary glaucoma with synechiæ, a peripheral iridectomy may be done. If there is no tendency to prolapse whatsoever, it is permissible to do a small triangular iridotomy here because the size of the sclerectomy opening is not so large, and the danger of subsequent iris prolapse is decidedly minimized. Holth's operation may be done almost as well through a ker-

[1] Brit. Jour. Ophth., December, 1921.

atome incision. The keratome is passed beneath a conjunctival flap, the scleral point of entrance being 2 to 3 mm. from the limbus. The keratome should pass quite obliquely through the sclera into the anterior chamber a distance sufficient to make a 5 to 6 mm. cut through the sclera tangential to the limbus. As soon as the keratome is withdrawn, the conjunctiva is pulled down toward the center of the cornea and freed with sharp dissection so that one jaw of the punch may be passed down readily through the keratome incision in the sclera. One of the blades of the punch forceps is passed through the scleral incision, the other blade above it, and the same size sclerectomy done as when a cataract knife is used. A peripheral or complete basal iridectomy concludes this operation with the exception of the suture which must be inserted as before.

Berens[1] presented a technique for irido-corneo-sclerectomy which he felt combined the best features of the Lagrange irido-sclerectomy, of the Elliot trephining operation, and of the Holth punch operation. Berens believes that the excision of tissue in the angles of the scleral wound, and the complete closure of the conjunctival wound over a bleb of salt solution, produces a broad, evenly spread filtering cicatrix. The technique as he presented it before the Clinical Congress of the American College of Surgeons is as follows:

After aseptic preparation and injection of the eyelids, inject subconjunctivally over each rectus muscle, 1 per cent with 3 minims of a solution of adrenalin (1 to 1000) to each dram of procaine solution In the operation performed recently, the ciliary ganglion was injected with 1 cc of procaine adrenalin solution. The conjunctiva above the cornea is ballooned with the adrenalin-novocaine solution. With Stevens' scissors, a slightly curved incision 15 mm in length, and 10 from the limbus, is made through the conjunctiva to the sclera with the concavity toward the cornea; this flap is dissected from the underlying sclera down to the cornea. Figure 477, *A* The extremities of the incision should be kept at least 8 mm. from the cornea The flap is folded back over the cornea and dissection is done with a flat, sharp spatula with a rounded end, gently into the layers of the cornea with a side to side movement With a blunt spatula placed between the layers thus dissected, and with the conjunctival flap restored to its original position, the point of the spatula should extend 1 5 mm. into the cornea. The eye is directed and held downward with a fixation forceps, and an incision is made with a broad, hollow ground keratome The incision is started in the sclera 1.5 mm. above the limbus and is extended into the anterior chamber until a wound approximately 4 mm. long is obtained, as in Figure 477, *C*. If the anterior chamber is shallow, the incision may be made with a short narrow, curved Graefe knife. While the keratome is being withdrawn, care is exercised to prevent the iris from prolapsing into the wound. If prolapse occurs, and it cannot be replaced readily, exclude the iris with a spatula while the punch is being used Stevens' scissors are used to extend the angles of the scleral wound for a distance of 0 5 to 1 mm., which makes an incision approximately 5 mm. long. The cuts should be parallel to the limbus and should allow the introduction of the special scleral punch into the angles of the wound. With the punch, the sclera and cornea (Figure 477, *F*) are clipped as deeply within each angle as possible; the remaining lip of sclera and cornea is then clipped, a serrated edge being left. The wound should extend 0.5 to 0.7 mm. into the cornea. A broad two cut glaucoma iridectomy is now performed After the first cut, the iris is torn from the ciliary body by traction forward and toward the uncut side. In selected cases of chronic non-congestive glaucoma, a peripheral iridotomy or iridectomy may be performed. The conjunctival wound is closed with an over and over running catgut suture (No 0000 plain) After the suture is drawn tight the wound edges, except at the extremities, are crushed with forceps; a grooved spatula is inserted in one angle; an anterior chamber irrigator filled with half-

[1] Am. Jour. Ophth , 19, 470, June, 1936; Clin. Cong Am. Coll Surg , San Francisco, October 28, 1935.

normal physiological saline solution is placed in the opposite angle; and all blood and fibrin are washed from under the flap. Sufficient solution should remain under the flap to balloon it forward and restore the anterior chamber if possible. The extremities of the wound are now crushed and closed with forceps. Metaphen ointment (1 to 2500) is applied over the inner canthus, and one drop of 3 per cent atropine is instilled.

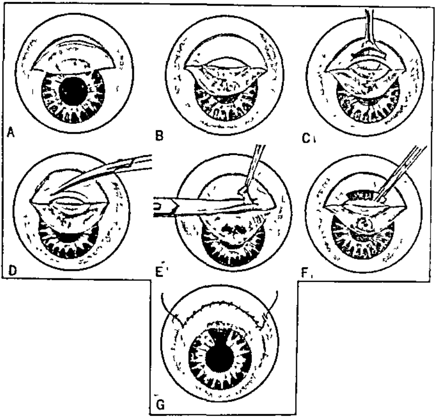

FIG. 477.—Technique of Berens' irido-sclerectomy. *A* and *B*, formation of flap, flap folded down for keratome incision, *C*, keratome incision, *D*, extension of incision with Stevens' scissors, so that incision is approximately 5 mm long, *E* and *F*, resection of scleral lip with scissors and punch, clipping with punch to leave a serrated edge, *G*, broad, Bowman type iridectomy.

Berens keeps his patients in bed for twenty-four hours with their heads somewhat elevated. Forty-eight hours after the operation, gentle massage of the eyeball is begun; this is repeated three times each day. Atropine is instilled to keep the iris well dilated. Under ordinary circumstances he omits a dressing, using only a mask over the eyelids. He states that complete closure of the wound reduces all exogenous infection to a minimum and leads to early reformation of the anterior chamber. The author takes exception to this omission.

Griscom's[1] modification and simplification of the Lagrange iridosclerectomy is a procedure used almost wholly by the author. His technique has the following advantages: one may choose the exact point for the scleral incision and the sclerectomy, the size and shape of the sclerectomy can be well regulated, a more thorough basal iridectomy is possible because

[1] Pennsylvania State Med Jour, 42, 640–642, March, 1939.

the pectinate ligament is itself incised, and a thick Tenon's capsule conjunctival flap overlies the fistula. The surgical procedure as he outlines it follows herewith in abstract. A broad flap which includes the conjunctiva and capsule of Tenon and which begins at about 7 mm. from the upper limbus, is dissected down to the corneal margin. After the flap is turned down over the cornea, a Tooke's corneal splitting knife incises a line 3 mm. long in the superficial layers of the sclera, 2 mm. above and parallel to the limbus. The step is very important, because the angle of the anterior chamber is 1.5 to 2 mm. behind the limbus. The assistant holds the conjunctival flap down over the cornea, the point of a keratome being placed in the prepared scleral incision. The flap is then turned up, to permit the angle of the anterior chamber to be seen from below. The keratome is

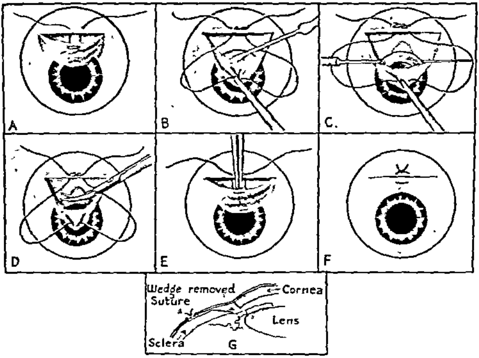

FIG. 478.—Technique of Spratt's pocket irido-sclerectomy. *A* and *B*, formation of flap, *C*, cataract knife incision, *D*, sclerectomy; *E*, iridodialysis, *F*, completed result; *G*, diagrammatic sketch of tissues removed.

firmly and slowly pushed both downward and forward, while the point is directed toward the apex of the cornea, until the assistant can observe the point in the angle of the anterior chamber when he looks from below. Until the point is observed, the direction must not change; otherwise, the keratome will almost certainly pass beneath the iris and thus injure the lens. The operator, from his position above, soon can see the point; then the direction of the keratome is changed, now passing downward parallel with and close to the anterior surface of the iris, until the incision in the sclera is about 5 mm. wide. The instrument is now swiftly withdrawn, the operator being careful not to injure the lens. The anterior lip of the scleral section is seized with iris forceps, and small curved scissors used to excise a piece of sclera, 1.5 x 4 mm. Following this, a broad basal iridectomy is

performed, and the conjunctival flap is sutured. Both eyes are bandaged, and the patient remains in bed for three or four days.

Spratt's pocket flap sclerectomy is described by him as a sclerecto-iridodialysis.[1] It is different from the de Wecker sclerotomy with iridodialysis in that it embodies a filtering cicatrix. Figure 478 illustrates the technique of his operation and its end-results shown in cross-section In view of Spratt's satisfactory end-results and because the operation is essentially a modification of the Lagrange, it is proper to include it herewith in fair detail. The technique as he presented it, is as follows·

The conjunctival sac is thoroughly flushed with from 1 to 3 cc of hexylresorcinol solution (S. T. 37) or metaphen, in a dilution of 1 to 1000. If the eye is hard, a posterior sclerotomy is done to relieve the tension and give greater depth to the anterior chamber. The insertion of a suture in the superior rectus muscle helps to maintain fixation of the eye. It should be used when the patient is unable to rotate or hold the eye steady. A horizontal incision 1 5 cm. long is made in the conjunctiva 10 mm. above the limbus. A thick flap which includes the conjunctiva and the subconjunctival tissue, is dissected to the limbus with scissors A small scalpel is used to separate the fibers of the conjunctiva from the limbus, the cornea is split for from 0 5 to 1 mm. A conjunctival pocket is thus formed so that the incision is made in a clean field. A mattress suture of No 000 black silk on a fine, full curve needle is placed in the edges of the conjunctiva, and the large loops are drawn to the side so that they will not be cut by the knife. The conjunctival flap is held down over the cornea by blunt forceps so as to obtain fixation of the globe A Graefe knife, 1.5 mm. in width with a long slender point, is introduced from 1 to 1 5 mm. back of the scleral margin, so as just to enter the anterior chamber, and the counterpuncture is made at a corresponding point opposite This incision is made as far back as possible. Since the incision is confined to the angle of the anterior chamber, there is no danger of injury to the lens, such as may occur when a keratome is used. The edge of the knife is turned backward so as to make a thick tongue of sclera 3 mm. long. The length of the limbal incision is approximately 4 or 5 mm. The wedge of the sclera is removed with curved scissors, as in the Lagrange operation. The conjunctival flap is next held up so that the iris may be distinctly seen. This is grasped at the root with delicate curved iris forceps having teeth on the convex side (Foerster model). The iris is pushed gently toward the center of the pupil, and separation of the root from its attachment to the ciliary body (iridodialysis) follows. The suture is drawn tight and the wound closed

Spratt uses atropine only if the patient complains of pain. He feels that the problem of iris prolapse is better answered by the iridodialysis than through the iridectomy. It is rather likely that there is a bit more hæmorrhage in doing the iridodialysis than with the iridectomy, but the originator of the operation stated that it never was of such a degree that it caused a real complication.

The indications and contraindications for irido-sclerectomy are rather sharply delineated. These contraindications exclude: (1) acute congestive glaucoma, (2) severe chronic congestive glaucoma, (3) iritic or uveitic glaucoma with congestion or irritation, (4) chronic non-inflammatory glaucoma in the lower ranges of hypertension, (5) chronic non-inflammatory glaucoma in the higher ranges of hypertension, (6) cataract, especially cataracta complicata. The diagnosis of cataracta complicata with a very possible fluid vitreous is a most positive contraindication because of the danger of dislocation of the lens and prolapse of the vitreous, (7) advanced arteriosclerosis, especially with arterial hypertension, (8) vascularization of the iris, and (9) buphthalmus. Ordinarily, in buphthalmus, irido-scler-

[1] Trans Sec Ophth , Am. Med. Assn , p. 135, 1933.

ectomy is not considered an ideal operation, but in spite of this, Delord[1] reported satisfactory results with its use, and Poulard and Lavat[2] reviewed the late results of 18 sclerecto-iridectomies for infantile glaucoma, and in two-thirds of the cases the tension was normal at reëxamination.

The operation seems to be indicated in: (1) Simple non-inflammatory glaucoma, especially in which miotics react favorably on the tension; (2) recurrent simple non-inflammatory glaucoma following an unsuccessful iridectomy. (Lagrange does a simple sclerectomy after an unsuccessful iridectomy to compensate for the inadequacy of the previous operation. Because it is performed at the site of the old scleral scar, he calls the operation oulectomy.) (3) Secondary glaucoma with synechiæ but without ciliary injection; (4) glaucoma following cataract operations; (5) for the completion of an iridencleisis operation wherein the tongue of iris has either been torn or an iridectomy was inadvertently made complete. The operation has been especially successful in recurrent simple non-inflammatory glaucoma wherein a prior corneo-scleral trephining has been insufficient in lowering the ocular tension to a normal degree.

Lagrange[3] discussed in detail the indications and contraindications for his operation as applied to the various forms of glaucoma. It is quite proper and apt that we should listen to the originator of the operation himself in these considerations. From a surgical standpoint he divides all cases into two subdivisions, depending upon the degree of tension present, and upon the depth of the anterior chamber. In considering the cases from the standpoint of tension, he (Lagrange) feels that sclerectomy is not indicated in acute glaucoma; instead scleral iridectomy is the operation of choice, and thereafter, if hypertension should again develop, to operate subsequently by a resection of the cicatrix, *i. e.*, oulectomy. A tension above 60 mm. Hg. is a contraindication, though if it can be brought down to 40 mm. Hg. by adrenalin, or by retrobulbar injections, then the longitudinal subconjunctival sclerectomy at the limbus is easy and proper. Therefore, 40 mm. Hg. should be considered as the maximum tension in order that sclerectomy will be free from danger. In so far as a very shallow anterior chamber is concerned, while the scleral resection can be made from without inwards, as done by Gayet of Lyons, Lagrange feels that it is best to use a small (1 mm.) trephine at the limbus so that only one-half of a scleral disk is cut, and as this is lifted and removed with a pair of sharp-tipped scissors, an elongated scleral tongue can be removed simultaneously without danger to the ciliary body. The conjunctival flap, prepared before the scleral trephining is done will permit the formation of an adequate filtration bleb as well as give sufficient protection.

In nearly every case where the anterior chamber permits, a section of the sclera must be performed with the knife or a keratome. One must remove from the anterior lip of the wound that portion of sclera which lies in the wall of the anterior chamber.

Curdy[4] in his presentation of a subconjunctival approach for the Lagrange sclerectomy, "ab externo," feels that he has by this eliminated the difficulties of cataract knife puncture and counterpuncture with a shallow

[1] Clin. Ophth., 28, 563, 1924.
[2] Ann. d'ocul., 162, 496, 1935, Soc. d'ophth. de Paris, p. 129, March, 1925
[3] Trans. Ophth. Soc. United Kingdom, vol. 47, 1927.
[4] Arch. Ophth., vol. 23, No. 6, June, 1940

chamber, the danger of injury to the iris lens and vitreous, obtains an equally satisfactory fistulizing cicatrix with less abrupt sides than those made with a circular trephine, and that there is less tendency to iritis than that seen after trephining. The technique, as he presents it, follows herewith.

A long horizontal incision is made in the conjunctiva about 8 mm above the limbus and undermined to expose the sclera down to the limbus This is the same as is done for the Elliot trephining operation, except that a longer arc of the limbus is exposed, and the cornea is not split. An incision is made along the curve of the limbus, about 6 mm. long, perpendicular to the scleral surface and close to the attachment of the conjunctiva at the limbus A second, more curved incision in the sclera is made above, its middle 1 mm or a little more from the middle of the first incision and its two ends curving to meet the two ends of the first incision (Fig 479, A) This second incision is not perpendicular to the scleral surface but inclined slightly toward the incision at the limbus The incisions are not made to perforate at first but are sufficiently deep to outline definitely the scleral crescent to be removed. The incisions are deepened slowly by successive light strokes of the knife, and as nearly equally as possible. When perforation occurs, the iris prolapses

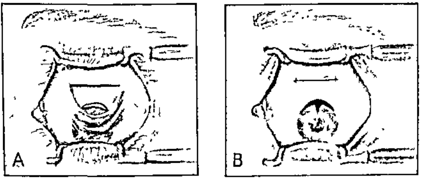

Fig. 479 —Curdy's subconjunctival sclerectomy, "ab externo"

as it does in trephining, and a peripheral or complete iridectomy can be done without the anterior chamber being entered. Of course, perforation occurs before the scleral crescent is entirely free, but the crescent can be grasped with fine forceps and dissected out easily, preferably after iridectomy Because of the converging of the scleral incisions, the deep opening of the fistula is a little shorter and narrower than the surface opening; the scleral crescent to be removed tapers to a point at each end and can be dissected out more easily than if the incisions were parallel and with less danger of injury to deeper structures. The iris replaces itself or can be made to do so by slight stroking of the cornea (Fig. 479, B).

The conjunctival flap is replaced and secured in position by such sutures as may be needed. A solution of atropine is instilled immediately after the operation and at subsequent dressings if needed The postoperative care is the same as for the Elliot trephining operation, though there is less tendency to iritis than after trephining.

Complications.—They are either immediate or late. When one considers conditions which are salient with an irido-sclerectomy, then one can understand the reason for the complications which arise, and at the same time, guard against these complications. Lagrange, in speaking of the necessary conditions connected with sclerectomy, and considering the modifications (as of Holth, of Kalt, of Foroni, of Lieto-Vollaro, and others) said the operation is best performed only when it fulfills the three following conditions: (1) a lengthened strip of sclera resected from along the filtering angle;

(2) care of the ciliary body and cornea; and (3) good conjunctival covering. The inability to obtain these requirements, it seems, is the basis for all complications save those accidental in nature.

Immediate Complications.—(1) Hæmorrhage from injury to the iris or to the ciliary body while using the cataract knife; (2) insufficient scleral ledge; (3) adherent conjunctiva; (4) prolapse of the ciliary body; and (5) dislocation of the lens and vitreous prolapse.

Late Complications.—(1) Hypotonia; (2) sympathetic ophthalmia; (3) cataract formation; (4) return of hypertension; and (5) secondary infection.

Injury to the iris or to the ciliary body by too oblique an incision is an ever possible complication. The hæmorrhage which occurs is sharp and obscures the operative wound. It will occur when the operator is having difficulty with adequate fixation. The immediate injury to the tissues is not the most unfortunate factor, but the fact that the subsequent sclerectomy places the filtration over the ciliary body or through it. This is decidedly not an advantage in that the dangers of sympathetic ophthalmia, at the worst, and of chronic long-standing iridocyclitis, at the best, are quite possible.

The opposite complication to that just described results when the exit of the knife edge is too abrupt, so there is no ledge of sclera formed for the resection. The causes for it are: difficulty with the fixation, perhaps and, more likely, the points of puncture and of counterpuncture were made too close to the cornea itself. These two complications are one of the best arguments for a keratome approach to this operation. If this complication should occur, it is best to complete the operation as an iridencleisis rather than a sclerectomy. This follows Greenwood's recommendation.[1] Iridencleisis to which a sclerectomy is added should not have its opening too far back in the sclera. If a keratome is used to make the conjunctival flap and the scleral incision, the point of entry must be carefully chosen.

If the conjunctiva is more adherent to the sclera than normal, the resection of the ledge of sclera will be quite difficult. The operation is indicated in certain cases which had had surgery before; therefore, this complication is not unlikely. Further, the same condition may be present if the case was preceded by a phase of congestion.

Prolapse of the ciliary body, even without immediate injury to it, is unfortunate. It occurs when the scleral incision has been made too far peripherally. The immediate resection of the prolapse may be followed by an uneventful recovery, but a staphyloma of the cicatrix is rather likely to occur and the loss of the eyeball from long-standing chronic low-grade inflammatory iridocyclitis. Blaskovics[2] disputes the idea that the ciliary region is a zone of special danger for either injury or for surgical procedures. To support this contention he cites the impunity of cyclodialysis. He thinks that the incarceration of uveal tissue in a wound is far more disastrous, and consequently argues for extensive removal of injured uveal tissue. He reports 5 cases in which portions of the ciliary body were excised. In 4 cases there were penetrating wounds over the ciliary area. In one the eye was lost through infection. The fifth was a glaucomatous eye in which cyclectomy was performed without success in the hope of reducing tension. Blaskovics considers cyclectomy, *per se*, a harmless

[1] Arch. Ophth., 10, No. 4, 476, 1933
[2] Ztschr. f Augenh., 88, 75, January, 1936.

procedure and fraught with no greater danger than is the excision of a prolapsed iris.

The lens should not be injured while making the scleral incision, even though the points of puncture and counterpuncture are somewhat removed from the cornea proper. An incomplete iridectomy, by reason of the iris falling in front of the knife, also should not occur because of the short length of the scleral incision. *Because, however, of the rather wide opening* of the anterior chamber, and the sudden abrupt loss of aqueous, dislocation of the lens may occur with a rupture of the hyaloid above and even with prolapse of the vitreous. When this complication does arise, it appears usually after the iridectomy has been done. There is nothing much that one can do in the case except to proceed immediately with a lens extraction. The sclerectomy has already been performed in all probability, and the incarceration of vitreous through the sclerectomy into the subconjunctival space would be a most unsatisfactory conclusion for the operation The incision will have to be enlarged with scissors, and a lens loop used for the extraction.

Subchoroidal hæmorrhage is always a possibility with arteriosclerotics, and especially when these cases are accompanied by more than moderate degrees of arterial hypertension. This condition is included in the contraindication already mentioned; therefore, it should not occur The abrupt change in the intra-ocular tension, from the earlier hypertension to the operative hypotension, because of the widely opened anterior chamber, is too great and too sudden for the pathological walls of the choroidal vessels to stand, even though the zonula is not ruptured. Evisceration is the end-result in such instances.

Hypotonia is apparently no more frequent with this operation than with a corneo-scleral trephining. In cases, however, of chronic simple non-inflammatory glaucoma with moderate degrees of hypotension, hypotonia may appear to a rather marked degree. This also is present where a trephining operation is done for a primary acute congestion glaucoma instead of a simple iridectomy. Such a surgical procedure is as much contraindicated, in general, as is the iridectomy not recommended for simple non-inflammatory glaucoma.

Iris prolapse is not common because of the iridectomy; ciliary body prolapse, however, may develop late after the operation. The posterior position of the sclerectomy, its width and length and the subsequent massage, it is indicated, may be precipitating causes. If it occurs it must be corrected surgically.

Iritis, chronic iridocyclitis, and sympathetic ophthalmia have been noted, as well as other complications, by various authors. The last of these should not occur unless damage has been done to the ciliary body at the time of the operation, or unless a subsequent prolapse of the ciliary body develops. Iritis and iridocyclitis, when they arise, must be combated as outlined under the complications of corneo-scleral trephining.

Late infections occur with this procedure as with corneo-scleral trephinings. According to the statistics of Lagrange, they are not as common under his care as with some other operators. Weeks[1 2] reported 1.3 per

[1] De Schweinitz Diseases of the Eye, 10th ed., Philadelphia, W. B. Saunders Company, p. 73, 1924.

[2] Weeks Diseases of the Eye, Philadelphia, Lea & Febiger, 1910.

cent of late infections in 389 Lagrange operations. Bentzen[1] routinely uses a sliding flap and feels that the separation of the conjunctival flap at the limbus gives the best protection against the so much feared late infection of the eye. The combating of it is the same as that covered for corneo-scleral trephining.

The incidence of cataract following late after an irido-sclerectomy seems to be highest of all the various filtering operations. This information was derived from the author's survey already mentioned. It is rather likely that the abrupt opening of the anterior chamber and the trauma to the lens and its suspensory ligament are the principal causes. Direct damage to the lens by instrumentation during the operation should not be included in this group because the manner of formation is quite different. The surgery of cataract extraction following an irido-sclerectomy is no more difficult, however, than when operating for a lens extraction with a filtering trephining bleb. (This does not condone the complication, but it is true nevertheless.) The technique for the extraction of such complicated cataracts has been discussed before.

CYCLODIALYSIS

Cyclodialysis is an operation first recommended by Heine in 1906.[2] As stated before, he became aware of an observation made separately by Fuchs and by Axenfeld relative to the occurrence of choroidal detachments following incisions into the anterior chamber.[3] He tried the procedure on 20 glaucomatous eyes that were totally blind or nearly so, and the experimentation demonstrated to his satisfaction that the procedure tends to reduce the tension even in cases of absolute glaucoma. There has been much written about cyclodialysis since that time. The differences of opinion which exist relative to it are inexplicable. Barkan, Boyle, and Maisler[4] studied gonioscopically 14 cases of glaucoma before and after cyclodialysis operation They concluded that Heine's original idea of establishing a communicating cleft between the anterior chamber and the supra-choroidal space was sound and an actual fact. Elschnig[5] studied histologically the eye of a patient normalized by cyclodialysis fourteen years previously. The eye showed a free angle and a patent Schlemm's canal and a communicating cleft between the anterior chamber and the supra-choroidal space at the place of the operation. On the opposite non-operative side, the angle was closed and Schlemm's canal mostly obliterated. Barkan, Boyle, and Maisler said that tension was normal in all cases in which this characteristic surgical dialysis was established. In those cases in which the ciliary body had become reattached to the sclera there was no permanent reduction of tension. Their conclusions, based upon their studies, were as follows:

> (1) The tendency toward closure was found to be due to too small a dialysis which favored adhesions of the contiguous surfaces; (2) trauma must be limited to a minimum in that trauma creates raw surfaces and stimulates closure through exudation; (3) it is necessary to obtain separation of the ciliary body with a spatula through a sufficiently large portion of its circumference, that is, from two-fifths to

[1] Trans Ophth. Soc United Kingdom, 47, 27[illegible] 1927
[2] Deutsch. med. Wchr No 21, p 824, 1[illegible]
[3] Beard's Ophth. Surg [illegible], p 12[illegible]
[4] Am Jour. Ophth [illegible] January, 1936
[5] Ber. d. deutsch. [illegible] Gesell., p. 277, 1[illegible]

one-half of its circumference; (4) the obtainment of these objectives is favored by making a scleral incision further posterior and even more diagonal than is customary, thus facilitating the entrance of the spatula in a tangential plane and its rotation through a large arc; (5) the anterior chamber should be preserved, (6) hemorrhage should be kept to a minimum, (7) postoperative instillation of mydriatics is to be avoided whenever possible in that mydriatics may favor closure of the dialysis by approximating the base of the iris to the site of its previous surface. (8) when the dialysis cleft is too extensive, hypotonia is likely to occur with a gradual primary cataract formation, or secondary by an increase in changes present in an already established incipient cataract.

We must therefore return to Heine's original premise and consider his theory, as to its mechanics, factual. Too often, inopportunely, the operation is relegated to a place reserved for intractable cases of glaucoma, that is, one in which previously performed operations have been unsuccessful, and the operator "now decides to try a cyclodialysis as a last resort "

Technique.—The operation may be done under local anesthesia, though even with the instillation of cocain into the cul-de-sac and a conjunctival injection of 1 per cent novocain, the actual disinsertion of the ciliary body is likely to be painful. Therefore, 10 per cent cocain solution should be at hand so that a small, tightly wound, cotton applicator can be dipped into it and applied directly over the region of the ciliary body for a few moments prior to the formation of the dialysis The proper time to apply it is immediately after the conjunctival flap has been formed. The position for the operation is at one of the four quadrants of the eye lying between the four recti muscles, up and out, down and out, up and in, and down and in Ordinarily the two external quadrants offer the easiest approach, though former surgical procedures and formerly performed cyclodialyses will modify the site which is to be selected.

A curved conjunctival flap 8 to 10 mm. in length is formed and dissected free from the sclera down to the limbus, the flap remaining hinged at this place. The sclera is bared at a point above or behind the ciliary body, that is 8 to 10 mm. from the limbus. An applicator soaked in adrenalin is held against this point for a few moments before the sclera itself is incised. This incision is made with the point of a keratome or the tip of a small cataract knife, the cut being made slightly diagonal, rather than purely tangential, to the cornea, and is carried through the sclera by successive light strokes of the cutting edge of the knife. It is slowly deepened until the absence of resistance to the knife indicates that the sclera has been perforated. Care must be taken not to incise the underlying choroid. (Meller, Török and Grout, and others have stated that there is less danger of this accident if the edge of a knife is used rather than the point.) At the same time, the incision may be made a bit longer. A medium width iris spatula, with a smoothly rounded tip, is introduced into this incision, its tip directed toward the cornea and with its point carefully and firmly approximated to the posterior surface of the sclera. If the juxtacorneal edge of the scleral incision is grasped with a fine-toothed forceps and elevated slightly, the introduction of the spatula is facilitated and its subchoroidal position more certainly assured. Spatulæ have been devised for this operation with transverse markings upon the upper surface, indicating the length of the blade in millimeters. This hardly seems necessary, though perhaps it might be advisable for an inexperienced operator. Before the spatula is introduced, it should be curved carefully into a paraboloidal shape, the least

curve being at the tip; the greatest curve present in the spatula must lie well posterior to the tip. Figure 480, *B*, illustrates a properly-shaped spatula. Of the various spatulæ, those which have a reverse curve are not recommended. There is no doubt that this reverse convexity does adjust itself better to the internal concavity of the sclera, but these spatulæ are more difficult to handle and, by reason of their shape, limit the cyclodialysis in its elevation from the sclera; *B* and *C* of Figure 480 illustrate this. With the tip of the spatula pressed against the posterior surface of the sclera, it is slowly and firmly, but gently, advanced until the resistance of *the pectinate ligament is felt. This is detached, and immediately thereafter* the tip of the spatula is seen in the anterior chamber. At least 2 or 3 mm. of the blade should appear within the anterior chamber; the tip,

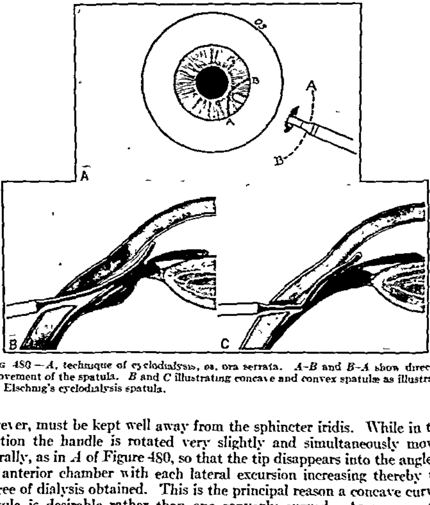

FIG 480.—*A*, technique of cyclodialysis, *os*, ora serrata. *A–B* and *B–A* show direction of movement of the spatula. *B* and *C* illustrating concave and convex spatulæ as illustrated in *C*, Elschnig's cyclodialysis spatula.

however, must be kept well away from the sphincter iridis. While in this position the handle is rotated very slightly and simultaneously moved laterally, as in *A* of Figure 480, so that the tip disappears into the angle of the anterior chamber with each lateral excursion increasing thereby the degree of dialysis obtained. This is the principal reason a concave curved spatula is desirable rather than one convexly curved. As soon as the maximum degree of detachment is obtained, by reasonable manipulation of the spatula acting with its fulcrum in the scleral incision, it is slowly withdrawn. A few drops of aqueous may escape with it. This is not only permissible but actually is desirable, in that with it, an immediate lowering of tension is obtained. This escape of aqueous will be facilitated if the blade is twisted the least bit while the spatula is being withdrawn. Again

here, however, the concave curve of the spatula will assure this almost certainly.

Barkan and his associates believe that the loss of aqueous at this time is unfavorable for the success of the operation. The writer feels that this loss of the aqueous itself is not the fault, but the trauma connected either with an attempt to drain the aqueous or the trauma from unnecessary roughness. Barkan, Boyle, and Maisler are again quoted in part herewith relative to their work with the gonioscope:

> Failures may be due to trauma during operation which creates raw surfaces and stimulates healing of the surfaces through exudation, and so forth. Thus, for instance, at the points where Descemet's membrane had been traumatized by the spatula, peripheral anterior iris adhesions are seen to have formed, counteracting the very object of the operation. Trauma encourages exudation and formation of iris adhesions in the angle just as it induces posterior adhesions of the pupillary border of the iris to the lens, more especially in that sector of its circumference which corresponds to the sector of the iris that has been dialyzed. The tendency to exudation and formation of the adhesions seems also to vary with the individual.

The conjunctival flap is then closed with a running suture and miotics immediately instilled to draw the root of the iris from the angle of the anterior chamber and to further assure the immediate persistence of the dialysis. The eye is dressed as is customary, and redressed daily, thereafter instilling miotics at each dressing. After the sixth day the suture may be removed and the miotics continued in frequency and in the percentage of solution necessary, depending upon the course of the postoperative tension. The operator should not depend upon finger tension for this. A bit of postoperative edema of the upper lid is not at all uncommon, and this amount is sufficient to interfere with the delicacy necessary for taking a satisfactory finger tension.

Recently the author changed his technique somewhat in this operation following a discussion on glaucoma surgery presented by Danielson, Long, and Sherwood[1]; a change which has proven most satisfactory. The conjunctiva is incised as is customary, parallel to the limbus in a crescentic manner at the site selected for the operation. This is reflected from the sclera and the sclera bared. Two a-traumatic black silk sutures are then passed through the sclera parallel to the long axis of the conjunctival incision through the superficial sclera, for a distance of 3 mm. each. The two sutures are separated one from the other about 1 mm. (see Fig. 481.[1]) Traction is placed upon these two sutures separating one from the other so that the intervening bridge of sclera is held taut. At the same time the eyeball is held rather firmly by this traction. A cataract knife or a Lundsgaard knife is then used to section the sclera. This is done also in a direction parallel to the limbus and with a smooth steady stroke. The length of the incision should be about 3 mm. As soon as the black choroid has been reached it shows in the sclera incision as a tiny black bleb because of the traction which is placed on the scleral lips of this wound. The cyclodialysis spatula is introduced as is customary, and the ciliary body detachment carried out. Closure of the wound completes the surgery. The two suture ends at one extremity of the wound, each from a separate suture, are passed through the conjunctiva. The same is done with the two sutures at the other extremity of the scleral wound. The two ends

[1] Am. Jour. Ophth., vol 25, No 24, April, 1942.

are then turned, one upon the other, and tied in a square knot—first the upper, the lower of the two thereafter. The latter of the two, however, exerts pressure when being tied in closing. Both conjunctival and scleral wounds are thus simultaneously closed. (See Fig. 481.[2])

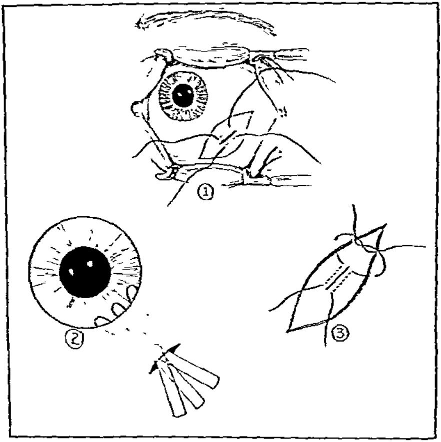

FIG. 481.—Technique after Danielson, Long and Sherwood, for control of the eyeball and for cyclodialysis.

Contraindications and Complications; Immediate and Late.—The outstanding contraindications to cyclodialysis are the presence of congestion, of ciliary and of iritic irritation, either present at the time, or with a history of it earlier in the case. By reason of the mechanics of the operation, any surgery which will exaggerate a preëxisting inflammation, or reëstablish a quiescent one, will also nullify the effects of the operation. It follows therefore, that iritic and uveitic secondary glaucoma are not proper cases for cyclodialysis. The presence of synechiæ, of descemititis, or of chorioretinitis, exudative or hæmorrhagic in character, may be considered as indicative of earlier or present inflammation. Simple non-inflammatory glaucoma, as a primary condition, is the outstanding indication for this form of surgery, but only when the tension is in the lower ranges of hypertension. Cases which respond fairly well to miotics, even if the tension should be at times above this qualification just stated, are also acceptable. Buphthalmus has been held fairly well by means of repeated cyclodialyses. The simple non-inflammatory glaucoma which one sees after [illegible]eventful

cataract extraction (whether primary or secondary) is also a condition wherein cyclodialysis should be seriously considered. The surgery, in that it lies wholly anterior to the vitreous body, is theoretically ideal for this. If slit lamp examination, however, should indicate extensive herniation of the vitreous into the anterior chamber, or if the glaucoma is very evidently secondary to incarceration of iris, or of capsule, then cyclodialysis is not recommended. Herniation of vitreous into the anterior chamber if well contained within an intact anterior limiting membrane and free from the angle, is not a contraindication.

Complications.—Immediate.—(1) Episcleral hæmorrhage; (2) incision of the choroid and choroidal hæmorrhage; (3) hæmorrhage into the anterior chamber; (4) supra-choroidal passage of the spatula and its appearance behind the iris in the posterior chamber; and (5) lacerations of descemet's membrane.

Late Complications.—(1) Return of hypertension, that is a failure from the operation; (2) hypotonia; (3) choroidal detachment; and (4) cataract formation.

Early or Immediate Complications.—Episcleral hæmorrhage may be rather common. The cyclodialysis opening is made ordinarily close to the exit of the anterior ciliary veins, and it is common knowledge that these are frequently dilated in glaucomatous eyes even without an inflammatory phase present. If it occurs, it must be controlled by adrenalin because the scleral incision cannot be made before it is controlled. The field of operation will be obscured and blood may be carried into the anterior chamber by the spatula. If adrenalin and direct pressure will not stop an episcleral or scleral hæmorrhage, then one must use the actual cautery. (An ordinary strabismus hook heated to a cherry-red color in an alcohol lamp is convenient and quite adequate.)

An incision of the choroid and a consequent choroidal hæmorrhage should not occur if the scleral incision is carefully and deliberately made in a field free from bleeding. The introduction of the spatula and the actual dialysis is painful unless the anesthesia is satisfactory and complete. The patient may, under these circumstances, wince or squeeze or be so unruly as to traumatize his own eye, resulting in a choroidal hæmorrhage, cause choroidal lacerations, and be responsible for a severe hæmorrhage into the anterior chamber. Hæmorrhage into the anterior chamber is usually venous and may result from blood being carried into the anterior chamber along the path of the spatula, by seepage or even perhaps by capillary attraction. A sharp arterial hæmorrhage into the anterior chamber is indicative of trauma to the root of the iris, and in such instances, the spatula should be withdrawn and a pressure bandage applied immediately.

A supra-choroidal passage of the spatula and its appearance behind the iris in the posterior chamber of the eye may be disastrous. The prolapse of vitreous into the wound is a certain indication of the perforation of the choroid and the retina. The initial introduction of the tip of the spatula, and its close approximation to the posterior concave surface of the sclera will prevent this most unfortunate complication. Occasionally, the tip of the spatula will appear in the angle, but it may be incarcerated in the iris stroma. In such instances, it can be very slightly withdrawn, the handle depressed even more, and then the introduction continued. One should be careful at this time, however, not to strip off a roll of Descemet's mem-

brane, the tip of the spatula acting as a little curet. The complication, if it occurs, is not really serious but it is unnecessary.

Laceration of Descemet's membrane and a splitting of the cornea occur more commonly not by the procedure just mentioned but because the spatula becomes entangled in the fibers of the pectinate ligament, the spatula entering the corneal stroma here and by its further advance splitting it. There should be some resistance normally to the elevation of the pectinate ligament, but any undue resistance is suggestive of the above mentioned entanglement. The tip of the spatula must be withdrawn for several millimeters and then again carried forward. Meller says the spatula generally finds its right way even in eyes in which the root of the iris is attached to the posterior surface of the cornea (peripheral anterior synechiæ), and that an iridodialysis is an exceptional occurrence.

Malignant early postoperative glaucoma is occasionally seen after all of the various surgical procedures which are done for glaucoma. Mauksch[1] feels that it is most common following cyclodialysis. By the expression "malignant glaucoma" is meant that ocular condition in which, either immediately or within a very few days after the operation, the eye becomes hard and the visual capacity as a rule is rapidly destroyed, with extremely severe subjective symptoms. The anterior chamber is lost. An iridectomy, if performed, then results in a gaping wound, and the lens may be pushed up and out into this. The condition in fact defies all efforts at surgical treatment.

The Late Complications of Cyclodialysis.—These are considered not so much as complications as they are failures from the surgery. The failures, however, are due to complicating factors. The indication of their presence is the return of hypertension. Peripheral synechiæ and the closure of the fistulizing channel and the ciliary body dialysis are the causes, but they cannot be seen grossly. Barkan and Troncoso described them gonioscopically, and pathologists have been aware of them even before gonioscopic observations were possible. An immediate fall in ocular tension is not the usual result from the operation unless an escape of aqueous is permitted. This would be, therefore, for practical purposes, only a paracentesis of the anterior chamber. The beneficial results are somewhat delayed and do not appear until the third, fourth, and even fifth day after the operation. Postoperative massage seems to have but little application as compared with the external fistulizing operations and to their reaction to this. If, because of a failure or an incomplete result, one feels that the operations should be repeated, it is wise to select a different site for the reoperation. Any one of four quadrants mentioned is available. In buphthalmus, repeated surgery may be done at a site previously operated, with apparent benefit. Certainly, a reattachment of the dialysis alone is not a contraindication to surgery at the same place, but an interval of time should elapse before it is repeated at this same place, so that postoperative exudates, inflammatory changes, and injuries to the pectinate ligament may recede to the normal.

Hypotonia occasionally occurs. Many, however, have considered softness of such eyes as quite harmless. The only importance which hypotonia plays is its possible relationship to the formation of a complicating cataract or to the exacerbation of preëxisting cataract changes. If vision drops to a

[1] Ztschr. f. Augenh., 72, 167, 1924.

degree where the patient is unhappy or wherein his earning capacity is impaired, the lens may be extracted without modification by reason of the cyclodialysis. The cyclodialysis operation itself, and the manipulations attendant to its performance, should not be the cause of lens changes. It is probably the least damaging of all of the glaucoma operations.

Cyclodialysis Combined With External Filtering Operations.—Scleral trephining has been combined with a cyclodialysis, and sclerociliary iridencleisis has been combined with cyclodialysis as well In general, these combined operations, in spite of the satisfactory results reported, are not whole-heartedly recommended by the writer They are difficult and too often are in the nature of frenzied surgery It seems much more logical to do as little as is necessary in any one case than to do as much as is possible. The combined operations impress one that the surgery is of this latter quality.

From the Halle clinic, where the method of Schieck is used, namely, scleral trephining combined with cyclodialysis, Schulz[1] analyzed the results of 197 cases. In 87 per cent of cases of glaucoma simplex, normal tension and improvement and preservation of the vision was obtained, and 78 per cent of the cases of inflammatory glaucoma showed satisfactory results. With Schieck's technique the trephining is done in the sclera at the limbus but without splitting the cornea. A peripheral iridectomy is then done, and immediately thereafter a cyclodialysis is performed, according to the usual technique, with the spatula entering from the anterior chamber at the site of the iridectomy. Schulz feels that the advantage of this subconjunctival scleral trephine over the more superficially placed corneoscleral trephining consists in a great lessening of late infections.

Sclero-ciliary iridencleisis with cyclodialysis is done according to the techniques of Mauksch and of Del Barrio. Each operator developed his technique, separately, one from the other; both, however, got equally good results. The technique of Del Barrio[2] is easier to perform and seems to be a bit more considerate of the ocular tissues An abstract of the technique from The Year Book of Eye, Ear, Nose and Throat for 1936 states that the operation is begun similar to a cyclodialysis. After the iris root has been separated from the sclera by the spatula, an iris hook is introduced through the scleral wound and advanced into the anterior chamber through the separated choroid and sclera. With the hook the free margin of the iris is pulled up into the wound, and a small iridectomy, including the sphincter, is then performed The iris is then allowed to remain folded back between the choroid and the sclera, separating the iris root from the scleral spur. The sutures are placed as usual.

Del Barrio feels that the operation makes the advantages of the cyclodialysis more permanent, in that the iridencleisis provides for drainage of aqueous through an epithelial lined passage between the anterior chamber and the supra-choroidal space.

Wheeler combines an iridectomy with cyclodialysis not grossly dissimilar to the above. This technique has been discussed under iridectomy.

Cyclodialysis Combined With External Filtering Operation by Means of Transplants Into Anterior Chamber.—Various men at different times have attempted to combine the advantages of a cyclodialysis with the per-

[1] Klin. Monatsbl. f. Augenh., 74, 771, 1925.
[2] Ann. d'ocul., 171, 977, 1934.

manence of external filtration. To achieve this, implants of all types have been used. Some of these in technique are not grossly dissimilar to the seton operation which has already been described. This latter procedure, however, has nothing of a cyclodialysis. It is essentially an anterior sclerectomy plus the implant. In so far as cyclodialysis is concerned, the function of the implants is to prevent a reattachment of the ciliary body to the sclera at the site of the operation. Materials, as horsehair, silk thread, and even living tissue, were used by various observers with no success at the best. The use of metals was also attempted and the results here were universally disastrous Magnesium, however, was tried by Morax and Chiazzo with good successes Unlike other metals, as Troncoso[1] states, magnesium is wholly absorbed in from two to three weeks forming hydrogen gas as it disintegrates.

After experimental work upon animals repeating and confirming the findings of Morax and Chiazzo, he (Troncoso) devised a technique which seems to be well worth consideration. This is especially so in the treatment of absolute glaucoma. The procedure is not recommended (author) in absolute glaucoma, as a result of a preëxisting iritis or iridocyclitis, because of the possibility of reactivation of such an iridocyclitic process. In other forms of glaucoma absolutum, wherein this possibility is improbable, the implants are to be considered.

According to Troncoso's technique, a scleral insertion is made 7 mm. from the limbus, the cyclodialysis is performed, and a strip of magnesium 2 mm. wide and 8 mm long is inserted under the conjunctival flap. This has been cut approximately 8 by 10 mm. in length, hinged above; 1 mm. of the strip of magnesium should protrude into the anterior chamber. The implant can be inserted rather readily by means of a specially designed carrier[2] which works on the cartridge ejector principle. A 0.5 mm. right angle lip prevents the strip from slipping either farther into the anterior chamber or wholly out of the chamber. The conjunctival flap is then sutured, and the case treated postoperatively with atropine. Postoperatively, the metal first changes to dull white, and then to black. Gas bubbles occasionally distend the flap. Reactions were present increasingly so at times for three or four days, with total subsidence in twenty days. Of the 12 operations Troncoso presented, the results were almost uniformly good.

Troncoso stresses the use of the gonioscope before operation, so that the opening into the anterior chamber may be made at a point where the angle is free of adhesions.

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[1] Arch. Ophth., vol 23, February, 1940

[2] Made by V. Muller Company, Chicago.

CHAPTER XXIV

THE ETIOLOGY AND DIAGNOSIS, THE INDICATIONS AND CONTRAINDICATIONS IN THE TREATMENT OF RETINAL SEPARATION

HISTORICAL

The modern treatment of separation of the retina is, perhaps, the outstanding single advance in ophthalmology within the present generation. Even this period, relatively short as it is, is definitely narrowed, in that the first article which initiated the recent research (and the tremendous strides which have been achieved) is that of Verhoeff's[1] of 1917. Then followed Gonin's work of 1919, '21, '23, '27, and '28, which will be mentioned again later; Larsson's work in 1928 and in 1930;[2] Vogt's in 1929;[3] Sourdelle in 1929;[4] and Gonin's in 1930,[5] all discussed operative procedures. Many various discussions of the etiology, theories of formation, and consideration of the histopathology also were presented in this interval, but for some reason the general ophthalmological world seemed dormant to the marvels which were occurring, at least unfolding, before them Even early articles connected with the surgical treatment passed unnoticed until attention was called to them by the tremendous amount of literature which suddenly appeared from 1930 on. Some of these early articles included that already mentioned by Verhoeff: Gonin's work of 1919, of 1921,[6] Lenz of 1922,[7] and Sourdelle's of 1923 and 1924,[8] in addition to the work of Jocos[9] It is interesting that the modern basis for surgery had been considered long before. Anderson,[10] in his very excellent bibliography connected with the treatment of this condition, calls attention to the "formation of adhesions" in this procedure, through an article by James Ware,[11] on electrolysis by Clavlier and Maraval,[12] and Terson;[13] and the provision for permanent drainage was emphasized as early as 1872 by de Wecker.[14]

Vogt,[15] with the help of his assistant, Latte, presented the following different dates:

Coccius[16] in 1853 was the first to see a retinal tear. The next was A von Graefe[17] who, however, regarded the tear as a part of the healing process, until Hansen[18] in

[1] A New Method for the Treatment of Retinal Separation, Ophth Rec., January, 1917

[2] Acta Ophth , 3, 319, 1926, Ibid , 6 344, 1928, Ibid , 8, 172, 1930.

[3] Klin Monatsbl. f Augenh., p. 719, 1929

[4] Pratique med franc., X année, No 3, 1929.

[5] Ann. d'ocul , 167, 961, 1930

[6] Correspondents Blätter für Schweizer Aerzte, No 44, p 1675, 1919, Ann d'ocul , 158, 175 1921.

[7] Handbuch der Augenheilkunde-Augenartzliche Operationslehre. 1289 1922

[8] Arch d'opht , 11, 419, 1923.

[9] Clin. Ophth , 9, 357, 1920

[10] Detachment of the Retina, Cambridge University Press, 1931, published for Brit. Jour. Ophth.

[11] Chirurg. Observations Relative to the Eye, 2, 238, 1805.

[12] Ann d'ocul , 115, 37, 1895.

[13] Ibid , 114, 22, 1895

[14] Ibid p. 137, September, 1872.

[15] Arch. Ophth , vol 10, No 3, September, 1933.

[16] Ueber die Anwendung des Augenspiegels, Leipzig, I. Muller, p. 131, 1853.

[17] Arch. f. Ophth. (Abt 1), 1, 358, 1854, (Abt. 2), 4, 238, 1858

[18] Bemarkninger om Nethindelosningens Behandlung, Hospitalstid, 14, 1, 1871.

1871 and Schweigger[1] in 1873 advanced the opposite view. De Wecker[2] in 1870 recognized for the first time that the tear was the cause for the detachment. In his book he described three types of retinal detachment: "décollement par distension, par attraction et par soulèvement." In the first two, according to him, the retinal tear is the direct cause for the detachment. In 1882 Leber[3] popularized this mode of development. According to him, every acute detachment which can be recognized with the ophthalmoscope is caused by a retinal tear. Martin,[4] de Wecker[5] and de Luca[6] introduced ignipuncture in the treatment of retinal detachment in 1881 After that time ignipuncture became generally accepted, particularly by French and English oculists, and was frequently employed. Schoeler[7] was the first to select the region of the retinal tear and the place of the beginning of the detachment as the site for operation. He injected tincture of iodine between the detached vitreous and the retina, in the neighborhood of the tear, and in the place of the beginning of the detachment; in other words, in the pre-retinal space. In his book he published an illustration from a case in which the retina became reapplied and the tear closed. Deutschmann[8] was the first to use ignipuncture at the site of the tear in a case in 1896, which, however, he seems to have forgotten. The case was fully reported in 1899. Xavier Galezowski[9] was the first to use ignipuncture systematically for a retinal tear and with success, in 1902 and 1903, a few years before his death. He not only performed ignipuncture on the tear, but aspirated the retroretinal fluid before this procedure. He[10] aspirated the fluid just as Gonin[11] did later, so that the retina could apply itself before the cauterization took place Je pratique l'aspiration du liquide et la galvanocautérisation de la partie déchirée de la rétine et de la choroide J'ai obtenu ainsi de bons résultats.

Gonin felt that if the hole can be made to close, the subretinal contents are absorbed and the detached retina resumes its normal position. He tried to achieve this closure of the hole by direct cauterization of its margins. With this technique, then, unexpected successes, as Gonin called them, were first referred to by him before the Swiss oculists at Bale in 1919, with great reserve, then in some Swiss or French reviews, such as *Annales d'oculistique*, 1921, and *Revue generale d'ophthalmologie*, 1923. Later, with a short description some typical cases were presented before the French, Swiss and German Societies in Brussels, Zurich and Heidelberg in 1925 and 1926. In 1927, Gonin showed at Berne several patients, the complete disappearance of whose detachments lasted for several months; and in the following year, at Lucerne, his colleagues, Siegrist of Berne, and Vogt of Zurich, referred to their own confirmatory experiences.[12] This was the first occasion on which credit was given to Gonin by ophthalmologists other than his own fellow-workers and assistants.

RETINAL TEARS

A disinsertion is an oval or slit-like rent in the retina occurring at the ora serrata, probably connected with cystic degeneration in the neighbor-

[1] Handbuch der speciellen Augenheilkunde, Berlin, A. Hirschwald, p. 456, 1873.
[2] Traite des maladies du fond de l'oeil et atlas d'ophthalmoscopie, Paris, A. Delahaye, p. 151, 1870.
[3] Klin Monatsbl. f. Augenh., 20, 18, 1882.
[4] Trans. Internat. Med. Congr., London, p. 110, 1881.
[5] Ann. d'ocul., 87, 41, 1882.
[6] Ann. di ottal., 12, 330, 1881.
[7] Zur operativen Behandlung und Heilung der Netzhautablosung, Berlin, Peters Verlag, pp. 28, 41, 86, 90, 93, Plate 1, 1889.
[8] Beitr. z Augenh., 40, 46, 1899.
[9] Congr. de chir., Paris, p. 417, 1902; Bull. Soc. franc. d'opht., 20, 214, 1903.
[10] Bull. Soc. franc. d'opht., 20, 214, 1903
[11] Rev. gen. d'opht., 37, 337, 1923.
[12] From a historical standpoint, the bibliography which appears in Duke-Elder, C. V. Mosby Company, 3, 2921–2926, 1940, is so complete that further references are wholly unnecessary in any other publication.

hood of the ora serrata. At this point the retina separates from its pigment epithelium, *i. e.*, there are no retinal elements, except the pigment epithe-

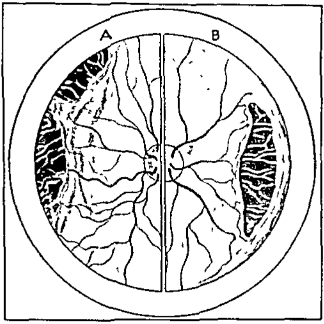


FIG. 482.—*A*, true disinsertion; *B*, drawing of a tear resembling a disinsertion

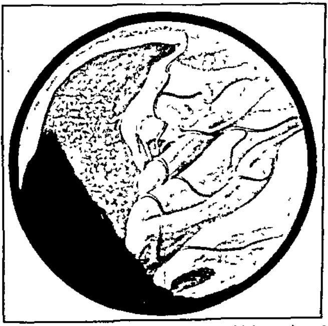


FIG. 483.—Traumatic tear from a direct blow to the eye, with hæmorrhage, before surgery, which was unsuccessful

lium, lying peripheral to the rent. Traumatisms and traumatic rents in the retina frequently stimulate these disinsertions (Figs. 482 and 483). Disinsertions may be multiple with the separate lobes close to each other. Two

or more of these may unite as a larger rent, and in such instances a small island or flap of peripheral retina can be found intact and still adherent to the ora serrata. These findings do not deny the statement just made, but simply indicate the process through which that disinsertion passed in its formation and in the formation of the peripheral flap still present.

A disinsertion is often difficult to find ophthalmoscopically. The folds in the retina prevent a view of the peripheral retina so that with even extreme dilatation of the pupil, it may be impossible to view the neighborhood of the ora serrata. In every case wherein the greatest elevation lies closest to the periphery, one must suspect this type of tear. Further, when a most careful search of the fundus, frequently repeated, fails to show a hole in the retina at any place, then also one should consider the likelihood of a disinsertion being present. Changing the position of the patient's head and his body in bed, or in a chair, so that the retinal folds can fall away by gravity from the periphery will, at times, permit the operator to see these disinsertions Preliminary subretinal drainage, with hypodermic syringe and needle, in the case of large bullous detachments, is permissible and may also uncover a probable disinsertion. Pressure upon the sclera, while viewing the fundus as far peripherally as is possible, has been suggested by Arruga as of great assistance. Transillumination along the circle of the ora serrata has been definitely valuable. Finding a disinsertion makes possible a much lessened amount of diathermy-coagulation in that the rent, in these instances, can be completely sealed from the remaining portion of the retina, and making unnecessary extensive treatment to the entire sclera overlying all of the separated retina; as would be almost obligatory in cases wherein no disinsertion nor other hole could be found.

The consideration of the remaining types of retinal tears is an interesting subject. The percentage of cases in which tears are found varies a great deal with the individual ophthalmologist. Arruga states that in 1925 he found rents in 40 per cent of his cases; in 1928, from 60 to 65 per cent of cases; in 1932, in 80 per cent of them, and at the present time, he is finding these in from 85 to 95 per cent of instances, depending upon whether these are cases of old or new separation. Tears are most readily found in new cases with the media still transparent, but as the weeks pass after the onset of a retinal separation, it becomes increasingly difficult to find them. Rest in bed, dehydration of the patient, and subretinal drainage, through scleral puncture, are not infrequently necessary before the hole can be found. Multiple rents in any one case appear in from 25 to 30 per cent. Because of this, the finding of a single hole should not halt further detailed search for additional tears. In the major number of instances, the tears are located in the superior half of the retina, the temporal quadrant first and the nasal quadrant second in frequency. The inferior temporal quadrant is third and the inferior nasal last in this order of incidence. This is diametrically different from the disinsertions, for in these their major number appears in the inferior periphery of the retina rather than in the superior. The order of frequency for tears from the periphery toward the macula is: (1) between the ora serrata and the equator; (2) in the macula itself; and (3) in this order of frequency is that portion of the retina which lies between the macula and the equator. The form or the shape of these retinal holes is as variable as are the innumerable potential probabilities. They may be many cornered; round or oval; in groups or in rows; arranged similar to the

perforations in coarse lace; subdivided by an overlying retinal vessel; lying between the branches of a retinal vessel; horseshoe- or crescent-shaped with the calks of the horseshoe or the horns of the crescent toward the periphery, in these instances with or without hinged flaps; large continent-like lacerations from trauma, involving sometimes an entire quadrant of the retina, and slit-like holes, narrow and elongated, resembling hæmorrhages and at times confused with hæmorrhages, also at times as a concentrated group of tiny sieve-like perforations. The macular holes are most commonly symmetrical, while those at the equator are usually of a crescentic or horseshoe shape. The region between the equator and the periphery presents the greatest number of varieties seen, while at the extreme periphery holes and disinsertions again assume a more regular outline, large, or spindle-shaped, and with their long axes parallel to the curve of the ora Traumatic lacer-

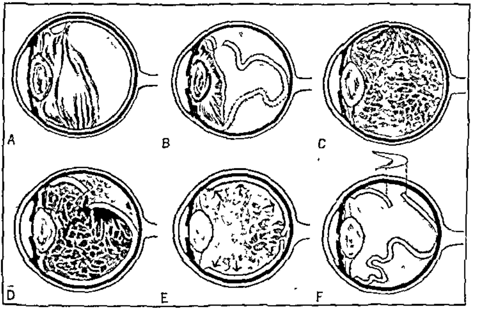


FIG 484 —Mechanics of retinal separation A and B, the formation of a retinal tear over an adherent contracting vitreous, C and D, retinitis with adherent bands in the contracting vitreous, E, the expansive effect necessary for a round tear in the macula, F, the formation of a horseshoe hole.

ations are of all varieties and shapes and usually are the largest in size Not commonly, but still not rarely, one may find both disinsertions and extra-peripheral tears present in the same case. Extra-macular and macular tears may also present simultaneously; this is more rare, but it has been observed.

Figure 484 shows (modifications from Gonin's illustrations) graphically factors in the formation of retinal tears. A and B illustrate a retinal tear from adherent contracting vitreous with the separation resulting above. The subretinal fluid in B can infiltrate from above in such instances with a minimal amount of separation there, but cause, by this infiltration, a maximum amount of separation below, as shown by the dotted position of the retina. This is a finding seen not uncommonly. In this instance, infiltration of vitreous through the tear is not as important as is the serous

fluid. In *C* an area of pre-retinitis has caused adherent bands in the vitreous to the vitreous surface of the retina. In *D* these bands have resulted in a minimal separation, at the start, with the formation of a hole. The separation has continued by the passage of vitreous through this hole, and not because of any continued traction upon the retina. Its force was expended when the retinal tear occurred. The damage was continued by the subretinal vitreous prolapse. The formation of the common crescent- and horseshoe-shaped holes is illustrated in *F*. From this drawing it is plain to be seen why this horseshoe-shaped hole is on the far side of a fold with its arm always facing the ora serrata. *E*, which is to be considered as a horizontal section of the eyeball, attempts to explain the explosive effect responsible for the round tears in the macula so common with separations which occur at the macula from traumatisms.

FIG 485 —Composite drawing to illustrate various holes seen in individual cases under varying circumstances *A* and *K*, the horseshoe-shaped holes illustrated in Figure 484, *F*; *B*, peripheral traumatic rent; *C*, *F* and *G*, a series of holes apparently coalescing, each to change into one large hole, *D*, peripheral-shaped rent with two flaps, *H* and *E*, linear tears which appeared on the dome of a bullous separation; *J*, a tear with a wrinkled flap; *M* and *L*, disinsertions

Figure 485 is a drawing of a case of actual retinal separation with a single hole in the center of the macula. There were no other tears, rents, or disinsertions present in this individual. The other holes illustrated have been sketched in at the approximate positions where they actually occurred in life in other patients, to illustrate some of the various rents found. *A* and *K* are the common horseshoe rents illustrated in Figure 484, *F*. *B* is a small peripheral traumatic rent. *C*, *F*, *G*, are a series of tears, slowly but steadily coalescing, and changing into one large tear. *D* is a peculiar shaped peripheral tear with two flaps, the larger of the two being folded in half, the smaller lying free, a bridge passed over this rent continuing a

large retinal vein. *H* and *E* are two linear tears which appeared on the domes of bullous separations. *H* was undoubtedly a rent at an area of choroiditis. *E*, following operation and the reduction of the separation, turned out to be a considerably larger tear bi-lobed with the larger lobe hidden underneath the fold. *I* is a tear at the extreme ora serrata which certainly resulted from a peripheral cystic degeneration of the retina. *J* is a tear with a wrinkled flap, very similar to one which Arruga demonstrated in the case of his. *M* and *L* are the appearance of the usual retinal disinsertions.

The summary in detail of two series follows herewith—that of Baer and Shipman,[1] and of Dunnington and Macnie.[2] The chart illustrates salient relationships. It is most interesting to see the close similarity in the percentage of many of these relationships.

Summary	Baer and Shipman	Dunnington and Macnie
Total number of cases reported	44	155
Female cases	31.8%	36.0%
Male cases	68.2%	64.0%
Cases in which myopia of varying degree was the refractive error	50.0%	61.0%
Cases in which 2 operations were necessary and done	27.2%	16.4%
Cases in which 3 operations were necessary and done	4.5%	4.5%
Cases in which retinal tears were seen	40.9%	56.0%
Successful results in cases in which tears were seen	55.5%	41.8%
Successful results in cases in which tears were not seen	38.4%	34.7%
Cases with history of injury including aphakia cases	29.6%	41.3%
Successful results in cases following injury	46.1%	36.6%
	5 cases with aphakia, operation done in 1 only	12 with aphakia 3 cured Hyperopia 41.6%, myopia 27.4%
Total cases with no improvement in field of vision and retina remaining separated	38.6%	51.7%
Total number of cases with slight improvement (retina partially reattached, field and central vision slightly improved)	15.9%	13.7%
Total of successful results (retina in place, field full, central vision improved)	45.5%	34.3%
Youngest case operated	16.0 yrs	5.0 yrs
Oldest case	79.0 yrs	75.0 yrs
Average age	45.5 yrs.	39.8 yrs

Retinal Separations From Traumatisms.—The force of the traumatism is not necessarily one of a great degree, in fact injuries from such objects as soft balls, a bump to the back of the head, a sudden jar in missing a step, are as frequent an etiological factor as are the injuries from a fist, sticks and elbows, from stones, a sharp edge of a door or the back of a chair. These all, as noted, are actual traumatisms as seen in various cases. Perforating injuries are somewhat different in this effect. In such cases, the choroid is also ruptured and perhaps even more extensively so that the hole develops suddenly and abruptly. Subchoroidal and subretinal hæmorrhages appear as precipitately, and the vitreous is injured simultaneously. Because of these three factors the separations may occur immediately, several days or weeks later, or even with a delay of several months. Further, in all traumatic separations one must not forget that while the trauma may be the real cause of the separation, some of these eyes may have been affected prior to the injury by undiagnosed forms of chorio-retinitis or iridocyclitis.

[1] Trans. New Jersey State Med. Assn., 1936
[2] Arch. Ophth., vol. 13, No. 2, 1935

The eyeball as it rests in the orbit is subject to posterior impact from the walls of the orbit, because of the resistance of the orbit to transient flattening of the eyeball from a blow. Because of its position, the major number of traumatisms will be applied from the front and slightly downwards. Repeatedly, retinal separation seems to be precipitated by minor traumatisms of such an inconsequential force and so distantly applied that their significance is oftentimes lost and not detailed by the patient in taking a history on the case. Because of the resistant bony orbital wall, retinal and choroidal rupture are not uncommon by contra-coup. The common macular findings in contusio bulbi and in commotio retinæ seem to indicate the delicacy of the retina at this point and the effects of contra-coup. The temporary deformity or flattening of the eyeball due to a blow probably accounts for the large irregular giant ruptures which occur in the region of the equator. The edges of the laceration are turned inward, *i. e.*, away from the sclera, and with the ophthalmoscope one can see that the enormous force, suddenly applied, plus the transient momentary deformity of the scleral shell, has resulted in an explosive rupture of the choroid and the retina together or alone. Theorizing on the formation of these giant traumatic lacerations, the retinal laceration may be due, not to the abrupt infolding, but to a sudden stretching from the impact to and the subsequent deformity of the scleral shell. While disinsertions are probably due to peripheral cystic degeneration of the retina or to peripheral degenerative chorio-retinitis, traumatic tears which appear in the pre-equatorial zone may simulate disinsertions. They probably are not true disinsertions but actual rents through a portion of the retina which was already thin and atrophic by reason of this peripheral retinal pathology. Choroidal and retinal ruptures, which occurred so commonly during the war as a result of bullet wounds in the neighborhood of the eyeball (without actual perforation of the eyeball), were undoubtedly of this same explosive nature. These showed the ruptures of contra-coup, ruptures through the posterior pole, and irregular and frequently huge ruptures, close to the path of the missile through the bony orbit. Perforations of the sclera may result in destruction of the globe, especially if the force of impact has been great or the missile large. Stab wounds, with the immediate withdrawal of the penetrating weapon, and smaller perforating wounds with probably retained foreign bodies, cause their retinal tears by (1) the perforation, (2) the loss of some vitreous, (3) the retraction of the lips of the wounds by contraction, (4) the continued gaping of these wounds by the deposition of scar tissue in the vitreous and in the path of the missile with consequent drag upon the retina, and (5) because of the hæmorrhage connected with the original wound and the very slow absorption so common with hæmorrhages into the vitreous. The frequency of retinal separation, following a posterior route extraction of magnetic foreign bodies, is quite significant.

APHAKIA AND RETINAL SEPARATION

Certainly preëxisting retinal conditions play a part, for it has been known for years that the myopic eye is prone to retinal separation following a cataract extraction. Cases of this type are to be considered probably, and essentially, as instances of myopia separation and are to be treated operatively the same as one would treat any other detachment not basically

traumatic. The elongated scleral shell, the preexisting myopic pathology, the very probable development of a larger optically empty space behind the contracted vitreous, anterior to the retina (because of the trauma and the structural changes following the cataract extraction), the probability of fluid vitreous, and the possibility of the loss of some of this are the physiological and structural factors responsible for this form of separation. They show of *all* cases least commonly a demonstrable retinal tear For this reason it is probable, though not proven, that many of them are the result of a retinal disinsertion. Further, they occur shortly after the cataract extraction and seldom, if ever, late.

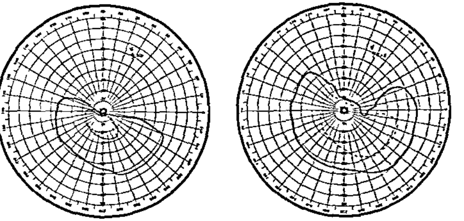
A later group of postoperative separations includes those cases which follow late after-cataract extractions, for the retinal separation of these is a distinct and definite type. After discissions, sometimes single, but more often when these have been repeated, separations are occasionally seen, after linear extractions for traumatic cataracts, and they are connected with cases that have had a stormy postoperative convalescence with iridocyclitis.

DIAGNOSIS OF RETINAL SEPARATION

The diagnosis of retinal separation is not always a simple matter, especially when considering the differential diagnosis of the condition The patient's complaint of impaired vision may have been preceded by subjective symptoms, vague and indefinite, many of them characteristic These have included photopsies and scotomata, described as flashes of light, flashes of colored lights, green circles, a green curtain, floating black spots, central scotomata and a definite sector loss in the field of vision, and as most cases of retinal separation occur in the superior temporal and nasal quadrants, the loss is in the inferior field. Metamorphopsia, a common complaint, is described as a distortion of objects viewed It may occur early as a prodromal symptom, or late because of the extension of the separation across the macula There are gross changes in the light sense threshold and in dark adaptation. The patients complain of a gross visual impairment when entering a dim room as a moving picture theatre, or the opposite: they suffer from dazzling in an illumination which ordinarily should not cause this. These cases show no acute inflammatory phase except those rare instances wherein the separation has developed before the complete recession of an iridocyclitis. An investigation of the central visual acuity, of the fields of vision, and of the light sense threshold is necessary. In regard to the fields of vision, it is especially interesting and important that attention be paid to the red and blue color fields, because these show to a marked degree the effects of choroiditic and retinitic changes. The color fields are in part prognostic, and following successful surgery they continue to show the damage which has occurred to those elements concerned with the epicritic retinal function The fields of Figure 486, *A* and *B*, illustrate these changes and the factors just discussed Most of the cases of retinal separation have a subnormal ocular tension, and in addition hypotension is roughly proportionate to the extent and severity of the separation. Another objective sign seen occasionally is a disturbance in the motility of the iris. Excluding those cases which already have synechiæ, there is a small percentage of cases further in whom it is quite difficult to obtain a satisfactory preoperative or postoperative dilatation of

the pupil. (This finding takes into consideration the fact that the dark irides always dilate with more difficulty than do those of from gray to blue in color.) Practically, the presence of synechiæ is a sign of great prognostic importance, so much so that surgery in these is seldom satisfactory. Cases in whom the pupils dilate with difficulty do not give as satisfactory operative results as those in whom a wide dilation is easily obtained and readily maintained.

Transillumination and the ophthalmoscopic examination are the most important of the examinations to be carried out. Both of them are intimately connected with differential diagnosis. The length of time a separation has been present controls the clearness of the vitreous. Inversely it is as well a means of estimating the duration of the separation. One can see the elevation of the retina, estimate its height, its greatest as well as least, the extent of the peripheral separation as well as the degree of macula involvement. One should be able to pick up and trace bands of proliferating retinitis, to locate the rents and disinsertions connected with these cases,



A B

FIG. 486.—Fields of a case of retinal separation A, before and, B, after successful operation The macula is again functioning with central vision.

and to decide upon the type of retinal separation which is present. The gray, flat, serous separation with its minimum amount of anterior displacement gives an entirely different picture than that wherein fluid has collected in varying amounts beneath the retina to cause overhanging gibbous blebs with large bulges, with folds of various sizes, and with intervening valleys which are frequently of great depth. The crests of these large folds are gray and shining. They may appear thinned out, and these folds often move with the movements of the eyeball, also change their position with great changes in the position of the head. The presence of hæmorrhagic subretinal fluids gives these separations a yellowish-green tint. This is best seen in the inferior separations which have been present for some length of time. At times there are no folds whatsoever to be seen, the retina simply shelves off from the ora serrata in a more or less hammock-shaped concavity directed backward toward the optic nerve papilla. At times a separation above is so extensive that it seems to fill the entire vitreous chamber, especially when the patient is in an upright position. The retinal vessels follow very closely the folds and elevations of the separa-

tion. In some instances, they seem to be ensheathed as if with perivasculitis. The veins often become a dark purple color—a certain sign of venous stasis in these veins. The extent of the macula involvement depends upon the individual characteristics of each case. The optic nerve disk is oftentimes slightly edematous and a bit suggestive of low grade papillitis. Hæmorrhages are occasionally seen even in the non-traumatic cases, though in the traumatic cases hæmorrhages are an outstanding characteristic. In the presence of giant or massive tears the separated retina has been lifted by the force of the blow, combined with the hæmorrhages which are always present; this separated retina may be twisted in the loops, blown outward into multiple ragged trapdoors projecting quite far into the vitreous, and even into rope-like formations. Arruga also showed this in one of his cases.

The possibility of a subretinal neoplasm or of a subretinal cyst must be seriously considered in every case under investigation. Small, peripherally placed neoplasms may cause a separation of the retina, in every way similar to a non-symptomatic type of retinal separation. In others, the retina will elevate about and above the neoplasm lying closely approximated to it in a dome-shape without folds, uniform in appearance, grayish in color, and the retina at the base of these elevations will pass over quite abruptly into normally appearing retina. Lindahl[1] studied 20 eyes with intra-ocular neoplasms and found that the retina in all instances was in contact directly with the most prominent part of the tumor, regardless of the size of the growth or the extent of the accompanying retinal separation. Hæmorrhage into the anterior chamber and a yellowish discoloration of the aqueous of the anterior chamber, Šafář[2] says, are an almost universal and characteristic neoplasm finding. Rönne[3] felt that this color is the constant sign for sarcoma and is rarely if ever due to any other condition. Fuchs spoke about the same thing many years ago in his classical text-book, as have also Arnold Knapp,[4] Meesmann,[5] and others. Meesmann, in his atlas,[6] spoke of a further use for the slit lamp in investigating the subretinal fluid by using a narrow intense beam. According to Anderson,[7] the borderland between the detached area of the retina and the normal fundus is indefinite, but by means of the slit lamp a sharp boundary may be seen some distance from the edge of the detachment. New formed blood-vessels upon the neoplasms have been seen rather repeatedly. Nivault[8] spoke of this, apparently, as an original observation. The rarity of retinal rents in separated retinæ, symptomatic, and the result of a neoplasm, has been confirmed by various authors. Lister,[9] in 1924, made a positive statement relative to the presence of a hole in these instances. He stated that if a hole can be detected, one may certainly and positively exclude the presence of a growth and, further, if one can substantiate a history of sudden loss of sight from detachment, even though a hole cannot be seen, one must be present, and thereby with equal certainty one can exclude growth. The

[1] Klin. Monatsbl. f. Augenh., 65, 11, 1920
[2] Arch. f. Ophth., 123, 19, 1930.
[3] Ber. u. d. Versamml. d. deutsch., p. 241, 1928.
[4] Arch. Ophth., 48, 559, 1919.
[5] Klin. Monatsbl. f. Augenh., 66, 417, 1920.
[6] Die Mikroskopie des lebenden Auges, Spaltlampen-Atlas, Berlin, Urban & Schwarzenberg, N. 24, 1927.
[7] Detachment of the Retina, Cambridge University Press, 1931.
[8] Study of the Retina With Red Free Light, Original Thesis, Paris, 1920
[9] Brit. Jour. Ophth., 8, 16, 1924.

retinal vessels follow the curvature of these neoplasms much more closely than in non-symptomatic forms of retinal separation. The ocular tension is plus rather than minus, hæmorrhages may appear, and the field defects are clear-cut sector losses without the accompaniment of gross red and blue field contractions. Fluctuation is absent, a rent is practically never found, and the retinal separation will not change its position or its shape with changes in the position of the patient's head and body.

All cases of retinal separation should be carefully transilluminated in all positions, and the cavity of the scleral chamber carefully studied through a dilated pupil under the effects of satisfactory transillumination, to eliminate any possibility of neoplasm. There are four important methods: (1) transpupillary illumination, (2) transconjunctival illumination, (3) trans-scleral illumination, and (4) transillumination of the pre-equatorial portion of the fundus, that is, the vitreous chamber in the neighborhood of the ora serrata

Transpupillary illumination consists in directing a narrow but intense beam of light through the dilated pupil and observing any possible variations in the degree of pigmentation of those tissues through which this light passes from the interior of the eye through the sclera. By this means one can normally follow the indentations of the ciliary body, and outline the ora serrata. Any tumor should interfere with the transmission of this beam of light and cast an appreciable shadow, the more pigmented the neoplasm, the more dense is this shadow.

Transconjunctival illumination is quite the opposite. The tip of the transilluminator is passed over all portions of the conjunctiva and the reflex, as it appears within the pupil, carefully observed. The amount of illumination used in this method should not be as intense as that degree necessary for transpupillary illumination. It is possible to augment this by direct observation of the interior of the eye with the ophthalmoscope. The various illuminating devices which have been recommended, demand specific and definite manipulations. The lamps of Lange,[1] Lindahl,[2] Guist,[3] and Dalen,[4] are all very satisfactory. In all of them, when one is studying the superior and nasal periphery, it will be necessary to rotate the eye out and down so that the tip of the light can be inserted for satisfactory transillumination.

The trans-scleral method is exactly the same as the transconjunctival, but it permits a more satisfactory posterior transillumination, even in the neighborhood of the macula or of the optic nerve papilla. Lancaster's[5] transillumination is the best for this. The conjunctiva and Tenon's capsule are incised and the sterilized tip of the Lancaster transilluminator passed posteriorly until it overlies that region under investigation.

The examination of the pre-equatorial portion of the fundus, according to Trantas' technique, is a modification of focused illumination plus digital pressure, or with pressure by means of a glass rod or a metal spoon. With pressure at the outer canthus using the cone of the transilluminator for applying pressure, one can control the entire eyeball for the examination of the ora serrata, the ciliary body, and the angle of the anterior chamber.

[1] Klin Monatsbl. f. Augenh , 44 1, 1906.
[2] Ibid , 52, 716, 1914.
[3] Ztschr. f. Augenh , 48, 219, 1922
[4] Klin. Monatsbl f Augenh., 75, 157, 1925
[5] Trans. Am. Ophth. Soc , 13 443, 1913.

The canal of Schlemm will also be in a satisfactory position for examination. He recommends a plus 10 to a plus 13 lens for the ciliary body and the ora, with a plus 8 lens for the ciliary processes. Focusing the light from the inner canthus toward the outer canthus with a plus 13, brings out into illumination the entire anterior chamber, clearly and distinctly, before the otherwise darkened eye, (see Fig. 487) showing the depth and the angle of the anterior chamber. Similarly, by directing the light through the eye from one side to the other, we can obtain, by reason of this focused illumination, an idea of the presence or absence of intra-ocular tumors or foreign bodies at the angle from the limbus posterior to the ora. Physiological salt solution may be injected retrobulbarly sufficient to cause an exophthalmos, permitting greater retro-transillumination for the determination of the presence of either a retinal separation or a pigmented neoplasm. Sachs,[1] in 1903, was apparently the first to combine pressure with transillumination to make possible a more detailed study of isolated regions of the globe. Less common means are also available, though ordinarily they are not of practical clinical value. The prismatic lens of Galezowski and the gonioscope of Troncoso are to be included in this.

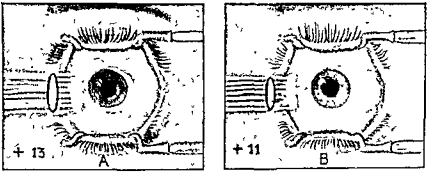


FIG 487.—Focused illumination for transillumination, in *A*, of the anterior chamber and ciliary body, *B*, from the ora posterior to the equator

Regardless of the type of transillumination used, serous exudates of long standing beneath the retina can clinically simulate sarcoma of the ciliary body. Shoemaker and Delong[2] presented a case which was enucleated because of extensive shadow upon transillumination which, following enucleation, proved to be an old iridocyclitis.

Because of other possible similar instances, one must be careful to give transillumination and the interpretation of the findings from it a due value, but no more than this, *i. e.*, it cannot always be considered conclusive.

In general, neoplasms have their origin close to the ora serrata, second, at the equator, and third, about the nerve head. These are the positions in their order of frequency. The first of the two mentioned are usually primary within the eye, are most commonly sarcomatous, and also usually pigmented. Neoplasms which appear at the ora serrata may be metastatic and depend upon the type and position of the primary lesion. The appearance of glioma and of pseudoglioma (*i. e.*, inflammatory metastatic ophthalmitis) should not be confused with retinal separation in any instance.

[1] Münch. med. Wchnschr., p. 742, 1903.
[2] Contributions to Ophthalmic Science, Jackson Volume, p. 146, 1926.

Acute chorio-retinitis juxtapapillaris, the neuroretinitis of hypertensive heart disease, massive exudative central chorio-retinitis, the exudative chorio-retinitis of nephritis, and retinal edema of traumatism, all simulate retinal separation, and must be differentiated from a true retinal separation by the careful ophthalmoscopic examination possible and necessary and through the other means of general physical and laboratory investigations at our command.

Retinal separation is dependent upon the presence of retinal tears, ruptures, and disinsertions, and successful surgery depends largely upon isolating and sealing these tears. Because of these two basic reasons, it is most important that the retinal rents be discovered whenever it is possible, so that the surgery can be carried out with this basic principle in mind. Failing the discovery of the rent or of a disinsertion, it is necessary that the ophthalmologists decide upon the most probable location for the undiscovered rent and treat this region specifically. Multiple rents are so common, as previously stated, that the finding of one tear should not prevent further detailed continued search for additional ones. There are some general principles connected with the finding of these tears which should be mentioned in detail.

1. Wide dilatation of the pupil.
2. Satisfactory ophthalmoscopic illumination.
3. Early examination while the vitreous is still clear.
4. Macular tears may be obscured or covered by reason of gibbous folds.
5. Disinsertions are greatest in number below, while the peripheral tears are most common above.
6. Red free light may reveal and differentiate minute tears from minute hæmorrhages and from unusual vascular appearances.
7. Tears are frequently gaping and with everted and edematous edges, so that the overhang of the thickened margin of such a tear may obscure it.
8. Areas of progressive thinning of the retina described by both Vogt and Elschnig as portions of the separated retina which, when first gray and later red, are regions to be carefully searched for the development of lace-like connected holes Elschnig considers these holes due to autolytic ferments in the subretinal fluid.
9. Holes are to be searched for in all regions of the retina wherein adhesions are still present or have been present prior to the separation.
10. The major portion of the small holes, especially those horseshoe- and crescent-shaped, appear in the narrow zone between the ora serrata and the equator, a region of 6 to 7 mm. in width.
11. Macular holes are sometimes one-half the width of the macula, are usually round or oval and oftentimes appear as if they were cut out with a punch.
12. Multiple yellow spots, yellowish-white spots, collections of pigment and other signs of chorio-retinitis; sharp and precipitous differences in the levels of the fold of the separated retina may all indicate or guide to the probable position of a tear.
13. Tears may appear at the extreme periphery of the retina which will simu[illegible] disinsertion, but in some of these instances a change in the po[illegible] head will permit the folds of the separated retina to fall awa[illegible]ssible to see that in such instances there is intact re[illegible] the peripheral lip of the rent and the ora serrata.

the chart appears sufficiently accurate for any case. By our method, the patient is placed chin in chin-rest, at a distance of 0.5 meter from a tangent screen, the affected eye on a level with and directly in front of the fixation point. He is told to rotate his eyes along the horizontal meridian as far as he can with a reasonable comfort. A small light is moved along the screen until its image is in the center of the cornea. A pin is placed in the screen at this point, and the patient is told to fix his eye on this point during the examination. The examiner now locates the lesion with the ophthalmoscope, using whatever angle is necessary. An assistant, with a meter stick or a piece of string, projects the line of direction, found by the examiner, back to the tangent screen. A mark is placed on the screen at this place.

Von Imre[1] ties one end of the string to the ophthalmoscope, while the other end is held in the position of the optic axis of the globe. Cowan and McAndrews continue:

The second angle found by the examiner must be corrected. In this oblique direction the rays of light emerging from the eye are bent away from the perpendicular, and the observer, falsely projecting these rays too far forward in the retina, places the lesion farther forward than it actually is. For practical purposes we may consider the ratio of the sines equal to the ratio of the angles of incidence and refraction in the proportion of 4 to 3 The horizontal and vertical angles used by the observer are, therefore, decreased by one-fourth. The angle through which the patient's eyes are turned, which is actual, remains unchanged. For example, it was found that the patient could turn his eye 50 degrees to the right. To locate the lesion, the examiner used another angle of 40 degrees on the horizontal and 20 degrees above. Reducing the horizontal angle of 40 degrees by one-fourth, it becomes 30 degrees. The total angle, therefore, in the horizontal meridian is 80 degrees. We must now correct the angle above the horizontal plane. This angle reduced by one-fourth becomes 15 degrees The final point, indicating the retinal tear, is now placed on the screen 80 degrees from its center on the 15 degree meridian. It now remains to find the corresponding point on the sclera. As was previously stated, the periphery or 90 degree circle on the chart corresponds to the ora serrata, which according to the accepted figures, lies 8 mm. behind the limbus. Supposing that we have located our point on the 15 degree meridian and 80 degrees from the center. by dropping a perpendicular from this point to the horizontal meridian, it will be found to lie 3.5 mm. from the periphery of the 90 degree circle. The 90 degree circle lies 8 mm. behind the limbus Adding the 3.5 mm. to this figure, we have the lesion located 11.5 mm. behind the limbus on the horizontal and 5 mm. directly above this point. Moreover, on this chart can be placed the position of the vorticose veins, the attachments of the recti and oblique muscles and the entrance of the ciliary vessels, thereby showing at a glance what anatomic structures must be avoided.

Figure 488 is Cowan's topography chart, with the various anatomical points marked thereon, and Figure 489 an actual case transferred to his field chart.

On the principle of Cowan's localization as he outlined it, Figures 490 and 491 are two of Marshall's charts illustrative of a case. Figure 490 is the ophthalmoscopic picture of the retinal separation as it appeared in the patient's left eye. It is simply a record and an ophthalmoscopic picture of the extent of the separation in a case. Transferring this to his chart, localizing the tear in this patient's eye as it appeared according to his method places the hole in the retina of this patient in the inferior temporal quadrant very slightly above the 45 degree meridian and at the exact equator. Figure 491 shows this separation transferred to a topographical chart to show the limits for the necessary surgery and to outline thereon the exact position of the hole. This chart is to be taken into the operating room at the time the patient is to be operated. This operating map is the

[1] A Simple Method for Localizing Retinal Tears, Klin. Monatsbl. f. Augenh., 84, 90, 1930

exact reverse of Cowan's chart, in that the macula and the *optic nerve disk* have been projected to the outside of a circle, while the center of the cornea holds at the center of curvature of the chart. Figure 486, *A*, is the field of vision obtained in the case for form and red. It follows roughly the degree of retinal separation seen ophthalmoscopically. Figure 486, *B*, is the post-operative chart eleven months after successful surgery.

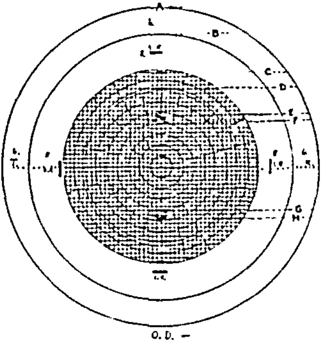


FIG. 488.—Cowan's chart for retinal localization. Topographic chart used as aid in localizing tears in retinal separations. *A* indicates the center of the cornea, *B*, the limbus, *C*, the ora serrata, *D*, the equator, *E*, superior oblique muscle, *F*, the superior vena vorticosa, *G*, inferior vena vorticosa, *H*, inferior oblique. (Cowan.)

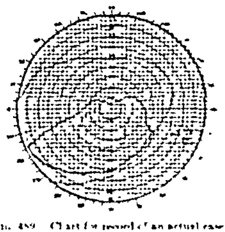


FIG. 489.—Chart for record of an actual case.

measurement in addition to those noted on the chart. It is useful to know that the distance from the corneal edge to the ora[1] is less in the horizontal

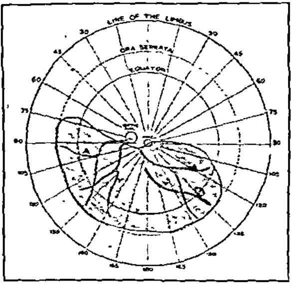


FIG 490 — Fundus drawing of a separation (Courtesy of J. Cole Marshall and Theodore Hamblin, Ltd)

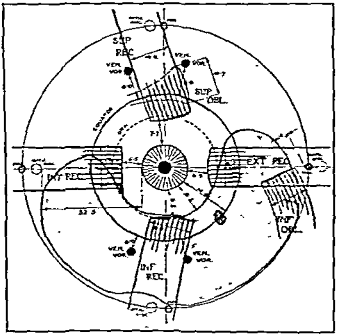


FIG 491.—After localization by Cowan's method Separation transferred upon Marshall's topographical chart to be used in the operating room for the surgery. (Courtesy of J. Cole Marshall and Theodore Hamblin, Ltd) Case of Figure 490.

than in the vertical direction, and generally less on the nasal side than on the temporal side. Marshall's average of the various measurements gives

[1] Detachment of the Retina, Oxford Medical Publications, 1930.

this distance of the ora serrata in the emmetropic eye as 8 mm. temporally, 7 mm. nasally, and in myopia increasing to 9 mm. as a maximum. It is best to estimate all distances with this measurement fixed from the ora serrata on the sclera. Therefore, from the retinal periphery to the papilla the averages, as given by Marshall and as quoted by Gonin and Schoenberg are: temporally 32.5 mm., nasally 27 mm., and superiorly and inferiorly each 31 mm. Fractional measurements are: from the center of the cornea to the limbus 5 to 6 mm., from the limbus to the ora serrata 7 to 9 mm. for the normal, and 9 to 10 mm. *for highly myopic eyes, from the ora serrata* to the equator 6 to 8 mm., and from the equator to the macula, 18 to 20 mm., slightly greater temporally than nasally. Goalwin's formula, as quoted by Schoenberg,[1] serves well for the calculation for the axial length of ametropic eyes.

The axial length of the emmetropic eyeball being 24.35 mm., to calculate the axial length in ametropic eyes, subtract from 24.35 mm. one-third mm for each diopter of hyperopia up to 10; add 0.5 mm. to 24.35 mm. for each diopter of myopia up to the first 10; add 0.6 mm. for each of the next 6 diopters, and 0.75 mm for each of the following 4 diopters.

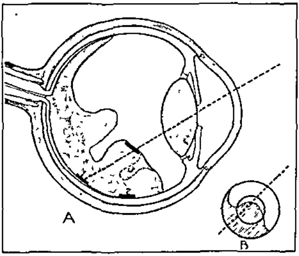


FIG. 492 —Retinal separation

The operator should not forget that the macula can be approached only on the temporal side of the scleral shell, in that the optic nerve papilla lies nasally to the macula and thereby limits approach to the macula. The estimation in disk diameters, assuming that each disk diameter is 1.5 mm., gives a fractional millimeter scale for transferring the ophthalmoscopic picture to the chart. There is one important factor, however, which must be remembered relative to this form of localization. Figure 492, *A*, is a cross-section of a retinal separation in the meridian illustrated at *B*. A hole as illustrated in the sketch would be correctly projected upon the sclera by any method if the retina lay properly coapted to the interior of the scleral shell, but because of its elevation, *i. e.*, antero-lateral displacement, visual or ophthalmoscopic localization might place it on the scleral shell at 1 instead of where it should be at 2. On the other hand, an addi-

[1] Arch. Ophth., vol. 6, No 5, November, 1931.

tional retinal fold between the ora and the hole, as dotted in at 3, would locate the tear at 2 while, as a matter of fact, it is to be projected more posteriorly than 2, depending upon the amount of infolding of the retina which appears between the hole and the ora. Further, with this patient in the prone position, the fold in the retina at 3 may smooth itself out to such a degree that a disk diameter measurement can be more accurately estimated. The example illustrates well the necessity of further localization in the operating room at the time of the operation. The defects in localization in such instances are probably minimized by utilizing a perimetric method.

Schoenberg[1] described Gonin's procedure. He (Gonin), according to Cowan and McAndrews, locates the retinal tear with the ophthalmoscope, and ascribes it to a meridian corresponding to the hour hand of the clock. A black silk suture is then passed across the cornea in the direction of this meridian. The distance of the tear from the ora serrata is estimated in disk diameters. Each disk is considered 1.5 mm. in diameter. The ora serrata is placed at 8 mm. from this limbus. The sum of these distances is the total distance from the limbus. In the hands of Gonin this method has given excellent results. For others less able it may prove inaccurate. Bearing in mind that the diameter of the disk is about 1.5 mm. and that many retinal tears are often no larger than a quarter of the disk in size, an error of only 0.5 mm. is sufficient to miss the tear completely. Moreover, the number of disk diameters from any landmark depends on the observer's estimation of distance, which is often inaccurate.

Lindner's[2] method is more elaborate and follows out the plan outlined by Cowan in 1920 and 1921. He centered the patient's eye by means of a Gullstrand ophthalmoscope, containing cross hairs, which are held in place by a special form of apparatus. Attached to the ophthalmoscope is a perimetric arc, the radius of which is 33 cm. The center of this arc is about 32 cm. from the patient's cornea. On the arm of the perimeter is a small, movable point of light. The patient is told to move his eye along this arc, following the point of light until the retinal lesion appears in the center of the ophthalmoscopic field. The angle and meridian is then read from the perimeter arc. Having found this angle, Lindner determines by his charts the corresponding distance of the lesion from the limbus. In order to locate this point on the surface of the eyeball, he uses a small model, shaped like the peripheral part of a contact glass. This model is slightly larger than the cornea and has fixed at its center a movable arm which reaches beyond the limbus. The arm is long enough to indicate the distance of the tear from the limbus and also its correct meridian. The model is sutured to the conjunctiva near the limbus, so that the horizontal meridian of the cornea and that of the model coincide. The location of the tear is then marked with the cautery on the sclera. The model is removed, and the operation is performed. To obtain the correct distance, Lindner assumed that the antero-posterior diameter of the globe is 24 mm. The second nodal point is 17 mm. from the posterior pole of the globe, including the sclera. He obtained the distance of the tear by the following formula, in which B is the unknown distance; a, the angle found on the perimeter, and r, the radius of the globe (12 mm.):

$$B \frac{a}{180} \times 3.1416 \times r$$

[1] Arch. Ophth., 3, 684, 1930. [2] Arch. f. Ophth., 153, 233, 1929.

Cowan takes exception to some of Lindner's measurements and computations. He feels that Lindner's estimation of 1 degree in the field to equal 0.2 mm. on the retina of an emmetropic eye should be 0.25. Further, using the perimetric method, Cowan and McAndrews insist that the amount of rotation which the patient obtains and can maintain with comfort, is seldom above 50 degrees; therefore this perimetric angle must be supplemented by a second angle which is obtained by the observer himself, according to Cowan's method of perimetric fixation as then detailed.

Salzmann[1] utilized von Graefe's original system in localization for the position of retinal pathology.[2] The patient fixes his eye on the center of the perimetric chart and the observer moves his ophthalmoscope along the arc of the perimeter until the retinal tear is found. This angle and its meridian are then noted. To transfer this meridian and the position of the tear to the sclera, it is necessary to determine three factors as outlined by Marshall,[3] (1) the exact meridian in which the tear lies; (2) the width of the tear or, if it is a disinsertion, the two extreme points of this disinsertion; and (3) the exact distance on the sclera from the ora at which the retinal tear lies.

Guist's ophthalmoscopic localizer is a large complete perimeter with a second arc arranged at a right angle to the first arc, the sliding arm arranged thereon for ophthalmoscopic localization on the retina, in any definite meridian and at any degree upon the second arc. Immobility of the patient is obtained, with his localizer, by having the patient fix his head firmly upon a rubber ring bite. The exact localization of the retinal hole or holes is then transferred upon a chart for permanent recording. In addition to this, he also has a small curved schema which is sutured to the sclera covering the cornea. The arms on this schema are graduated and used for marking the area selected upon the sclera for trephining. As soon as these points are marked with a few turns of the trephine, the schema can be removed and the surgery continued.

The writer has used almost exclusively for the past several years Stine's *method.*[4] *It is as follows:*

A small perimeter with a radius of 19 cm., such as Schweigger's, is most practical and convenient, as it can be used with the patient in any position It is held by the patient or assistant with the vertical arm parallel to the vertical plane of the face, care being taken not to cant the instrument to right or left, lest an error in the meridian be produced. With the perimeter arc turned out of the way, the surgeon, close to the eye, sights the tear and keeping the image of the tear in view *in the center of the pupil slowly backs away to clear the perimeter arc* which is now rotated until it intercepts the ophthalmoscopic beam. One notes then where the beam strikes the perimeter arc which is the perimetric angle (angle R) between the patient's visual axis and the surgeon's line of sight to the tear. The meridian of the arc is also noted. See Figure 493, *A* and *B*. Then by entering Table 5 (or 6 if the detachment is highly elevated) the corresponding distance of the tear from the limbus to be measured on the sclera is immediately obtained If the tear is on an oblique meridian one merely interpolates between the values for the horizontal (nasal or temporal) and vertical meridians. For example, let a retinal tear be localized at 70 degrees on the 135th meridian, that is, in the lower nasal retina. In Table 5 the limbus distance on the scleral arc (LScS) is 12.4 mm. on the nasal horizontal meridian and 11. 29 mm. on the upper or lower vertical meridian. Interpolating for the 135th meridian halfway between the horizontal and vertical planes, one obtains 11.85 mm. as the correct limbus distance. For the scleral chord the distance would similarly be the mean of 11.93 and 10.92 or 11.42.

[1] Arch f. Ophth., 153, 252, 1929.

[2] Arch f. Ophth , 28, 187, 1882.

[3] Detachment of the Retina, Oxford Medical Publications, 1936

[4] Am. Jour Ophth , vol. 17, No. 4, April, 1934.

TABLE 5 (STINE).—THE LIMBUS DISTANCES ON THE SCLERAL ARC AND CHORD IN MILLIMETERS CORRESPONDING TO THE DEGREES IN THE FIELD (<R) AS FOUND ON THE PERIMETER. CORRECTED FOR ANGLE ALPHA (5 DEGREES). (DATA SMOOTH TO THE NEAREST 0.1 MM.)

Observed angle (<R)	Sclera Arc: LSes Quadrant of globe Nasal	Temporal	Vertical	Chord: LS Quadrant of globe Nasal	Temporal	Vertical
95	7.7			7.5	....	....
90	8.4		7.7	8.1	...	7.5
85	9.2	7.7	8.4	9.0	7.5	8.1
80	10.2	8.4	9.2	10.0	8.1	9.0
75	11.3	9.2	10.2	10.9	9.0	10.0
70	12.4	10.2	11.3	11.9	10.0	10.9
65	13.6	11.3	12.4	12.9	10.9	11.9
60	14.9	12.4	13.6	13.9	11.9	12.9
55	16.2	13.6	14.9	14.9	12.9	13.9
50	17.6	14.9	16.2	15.9	13.9	14.9
45	19.0	16.2	17.6	16.8	14.9	15.9
40	20.4	17.6	19.0	17.8	15.9	16.8
35	21.9	19.0	20.4	18.6	16.8	17.8
30	23.3	20.4	21.9	19.5	17.8	18.6
25	24.8	21.9	23.3	20.2	18.6	19.5
20	26.2	23.3	24.8	20.9	19.5	20.2
15	27.7	24.8	26.2	21.4	20.2	20.9
10	29.2	26.2	27.7	22.0	20.9	21.4
5	30.7	27.7	29.2	22.4	21.4	22.0
0	32.2	29.2	30.7	22.8	22.0	22.4
Equator	11.7 (73.2°)	11.7 (63.2°)	11.7 (68.2°)	11.3	11.3	11.3

For myopia of −10 D multiply LS × 1.16
−15 D multiply LS × 1.25
−20 D multiply LS × 1.33

TABLE 6 (STINE).—THE LIMBUS DISTANCES IN MILLIMETERS ON THE SCLERAL CHORD (LS) CORRESPONDING TO DEGREES IN THE FIELD (<R) AS FOUND ON THE PERIMETER, CORRECTED FOR THE CHANGE OF POSITION OWING TO COMPLETE DETACHMENT OF THE RETINA. CORRECTED ALSO FOR ANGLE ALPHA (5 DEGREES). (DATA SMOOTHED TO THE NEAREST 0.1 MM.)

Quadrant of the Globe

Observed angle (<R) degrees	Nasal: Corrected angle (<R') degrees	Nasal: LS mm.	Temporal: (<R'), degrees	Temporal: LS mm.	Upper: (<R') degrees	Upper: LS, mm.	Lower: (<R'), degrees	Lower: LS, mm.
95	95.0	7.5					....	.
90	91.0	8.0			88.0	7.8	.	....
85	86.5	8.7			84.2	8.3	83.5	8.4
80	83.5	9.3	75.5	8.9	80.0	9.0	78.3	9.3
75	80.7	9.8	69.6	10.0	76.7	9.6	74.2	10.1
70	77.7	10.4	65.4	10.9	73.7	10.2	70.7	10.8
65	75.0	10.9	61.8	11.6	71.0	10.7	67.7	11.4
60	72.7	11.4	58.2	12.3	68.6	11.2	65.0	12.0
55	70.0	11.9	56.5	12.6	66.5	11.6	62.5	12.4
50	67.7	12.5	54.0	13.1	64.0	12.2	60.0	13.0
45	64.5	13.0	52.0	13.5	61.5	12.6	57.5	13.4
40	60.5	13.6	50.0	13.9	59.2	13.1	55.0	13.9
35	58.0	14.3	47.7	14.4	56.6	13.6	52.2	14.4
30	54.3	15.1	46.0	14.7	54.2	14.1	50.0	14.9
25	49.7	15.9	44.0	15.1	51.5	14.6	47.5	15.4
20	43.0	17.2	42.0	15.5	48.5	15.2	44.5	16.0
15			40.5	15.8	45.0	15.9	41.5	16.5
10			38.5	16.2	40.0	16.8	37.5	17.3
5			36.0	16.6	32.3	18.3	32.0	18.3
0			33.5	17.1			16.5	20.7
−10			26.5	18.4				....

See drawings of Figure 494, *A*, *B*, *C*, for the explanation of these above measurements.

Limbus distances on the arc (*LScS*) may be measured clinically with a curved rule such as Walker's scleral rule, and for the chord (*LS*) calipers or compass are used. Points of reference at the limbus and on the sclera may be marked by a fine toothpick dipped in 10 per cent gentian violet in alcohol and water and dried. At the beginning of the operation the position of the vertical and horizontal meridians and the meridian of the tear are marked on the limbus. Measuring around the limbus each meridian degree equals 0.1 mm., and on the equator 0.21 mm. The position of the equator on the tear meridian is then marked and with this and the limbal points as reference the position of the tear is measured and marked. A localizing puncture with a diathermic or galvanic micropin is then made and the position of the coagulation focus or the electrolytic tracer hydrogen bubbles with respect to the retinal hole is then checked with the opthalmoscope.

FIG. 493.—Stine's method of localization using the Schweigger perimeter.

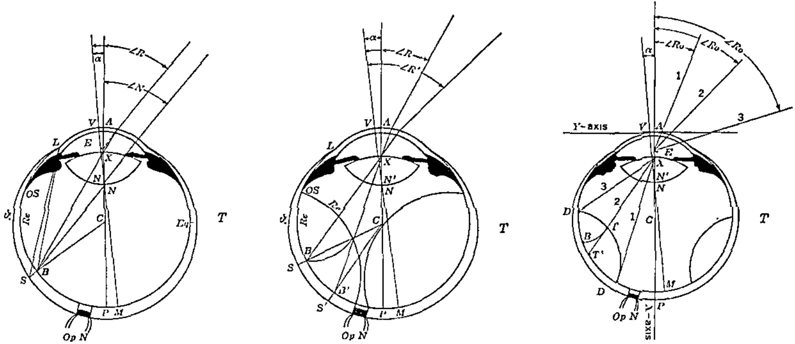
Knowledge of certain topographical landmarks on the globe is important. The vortex veins, scrupulously to be avoided during operation, are four: the superior temporal and nasal, and inferior temporal and nasal. They are located approximately on the four corners of a square with the optic nerve at the center. The superior pair emerge from the sclera 7 mm. (nasal vein), and 8 mm. (temporal vein), and the lower pair 5.5 and 6 mm. behind the equator. Thus the temporal pair lie closer to the vertical meridian than the nasal pair, and are in closer relationship with the oblique insertions. The ora serrata is approximately 7 mm. from the limbus in the nasal quadrant and 8 mm. temporally. The retinal equator projected to the scleral surface is 11.7 mm. from the limbus. The macula is located 29.2 mm. from the limbus on a line or great circle running from the upper limbus through the upper edge of the external rectus insertion, backward just above the insertion of the inferior oblique.

With regard to localization, Walker[1] expressed himself as follows: (His system of localization in its completion is a combination of preoperative measurements plus confirmation of these measurements at the operating table. The latter part of his description perhaps should be presented later in discussing technique, but it is probably best to incorporate it here and then to call attention to it later on.)

With regard to localization and technical procedures, it is a great relief to feel that one does not have to be quite so precise in locating tears as was previously thought. Yet I believe the tear must be localized as definitely as possible and given special consideration in the treatment. I have found a slit ophthalmoscope (Frieden-

[1] Am. Jour. Ophth., 17, No. 1, 11, 1934.

wald, with the mirror properly tilted) of great aid in obtaining the first approximation of the meridian of the tear before operation, a fountain pen or skin pencil being used to dot the streak where it crosses the orbital rim. The perimeter is used to check this axis as definitely as possible, together (by means of eccentric fixation) with the degrees of field from the macula. A 25 per cent reduction is applied to that part of this total angle added by moving the ophthalmoscope away from the perimeter center (*cf* Cowan). Then using 3.75 to 3.1 degrees of field according to the size of the eyeball up to -18.00 D. S. as equal to 1 mm. on the sclera along a meridian, we are in a position to localize the tear as regards distance in millimeters from the equator, which may be roughly taken to represent 71 to 72 degrees of field circle if the ora serrata represents 90 degrees. These measurements are then also checked by using the 500 mm tangent screen method. Here again the Friedenwald ophthalmoscope is used by fitting my (Walker) crossbar localizing attachment a little longer than the width of the observer's head into the slot designed to hold the telescope on the back of the ophthalmoscope head. The arms of the crossbar are exactly equal. Two strings of equal length (about 600 mm.) are attached to the ends of the crossbar and knotted together at the other end after passing through a loose-fitting short glass tube. This gives a triangular pointer of variable length with which one's assistant can accurately extend the line of observation back to the 500 mm. or 1000 mm tangent screen. But at the operation all these data are checked by using the scleral ruler (a scleral ruler, curved to fit the curvature of the sclera, subdivided into millimeters—Author) and micropins in the following manner First the horizontal, vertical, and tear meridians, as obtained by slit ophthalmoscope, are dotted at the limbus by boring a little with a hypodermic needle dipped in gentian violet or other tissue stain, or by sparking a dot with a microtip. After the sclera is exposed by a conjunctival incision along the ora serrata in the desired area, a canthotomy may be performed, and recti muscles neighboring the tear area may be either drawn aside by ligature slings only, or, in addition, a rectus muscle tendon is divided, if necessary, after marking the point where it is apparently traversed by the horizontal or vertical meridian. At this stage I (Walker) may use the scleral ruler and micropuncture pins to check localization in the following manner, which is perhaps my own variation in that I use it to measure along the great circles of the eye not only from limbus or ora serrata to the equator, but also along the equator at right angles to the meridian. Let us say, for instance, that the tear is noted to be on the 15 degree meridian on the temporal side of the vertical line above, and is estimated to be 2 mm. behind the equator. The scleral ruler, having a total length of 13 mm. (distance of limbus to equator) and a sharpness of teeth which will prevent it from slipping on the sclera, is laid along the vertical meridian (passing between the middle and the internal third of the superior rectus stump as marked before cutting) to reach the equator and a micropin, threaded in white, is inserted at this point. This is our first marker in the separated area. Also a spark dot with the stylus can be used though it grows fainter later, and an ink mark spreads out too much. The scleral ruler is now used to measure off ($15 \div 4.75$) 3.15 mm along the equator to the temporal side, at right angles to the vertical meridian already established, reaching the 15 degree meridian. The following values have been found quite practical: *(90 degrees of field along the scleral equator* 18.85 mm. (taking the scleral diameter of 24 mm), or 1 mm. = 4.75 degrees and decreases about 0.06 degree for every diopter of myopia; but 90 degrees of field along a scleral meridian from macula to ora serrata = 23.85 mm., or 1 mm. = 3.76 degrees, yet decreasing in myopia to 3.1 degrees at about -18.00 D. S. and increasing in hypermetropia to 4 degrees at about $+6.00$ D. S). Now it is only necessary to put another threaded tracer micropin at this point and measure along this meridian 2 mm. behind the equator, at which point a third micropin is inserted, which, if time permits and it is deemed necessary, may be observed with the ophthalmoscope in or near the tear, if the retina is not elevated too much. Of course, in myopic eyes it is also necessary to calculate the position of the landmarks for each case, especially as regards the equatorial measurements, on the basis that every 3 diopters of myopia indicate an increase of 1 mm. in the axial diameter. But in large bullous separations, which carry the tear toward the center of the eye, a still more difficult problem is presented. The tear may be seen to chart only 30 or 40 degrees from the macula, yet if one constructs a scale diagram of elevations from the sclera it may become obvious that the tear must have originated from the



A *B* *C*

FIG 494 —*A*, Stine's horizontal meridional section of anatomical schematic eye showing the nodal ray and ray refracted through the actual pupillary center; *VM*, visual axis, *AP*, optic axis; *L*, limbus, *OpN*, optic nerve; *M*, macula, *P*, posterior pole of retina, *EO*, equator, *OS*, ora serrata, <*PNM*, <*VN'A*, <alpha; <*R*, angle between emergent refracted ray and visual axis found on perimeter, <*N*, angle of nodal ray and optic axis, <*BNP*,*N*, posterior nodal point, *N'*, anterior nodal point, *C*, center of curvature of retina, *B*, point on retina where ray strikes, *S*, prolongation of *BC* to sclera *Sc*, sclera, *Re*, retina, *LScS*, limbus distance on scleral arc, *LReB*, limbus distance on retinal arc *LB*, limbus distance on retinal chord, *LS*, limbus distance on scleral chord, *E*, pupil of entrance; *X*, pupil of exit.

B. Retinal separation on the nasal and temporal quadrants *R*, retinal tear, *B*, corresponding position of lesion on normal retinal surface, *B'*, projection of *T* to retinal surface along vitreous ray, *XTB'*; *S*, *S'*, corresponding scleral points, *Re'*, completely separated retina, *Re*, normal retinal position, <*R*, angle of emergent ray from lesion *T*; <*R'*, angle corrected emergent ray from *B*

C Geometric construction of incomplete separation, *D*, *D'*, limiting edges of separation, *T*, retinal tear, *T'*, projection of *T* to normal retinal surface along sighting ray; *B*, real corresponding position of lesion *T* on normal retinal surface <*Ro* (1 2 3) emergent angle between determining rays to D, D', and *T* and the optic axis, *AP*, also *X* axis, *DTD'*, incomplete retinal separation

50 or 60 degree region, and then with the ora serrata as a center it swung toward the midline until it rested just about as far from the wall of the eye as from the ora serrata. Thus a full 20 degrees would have to be added to the apparent distance from the macula. A scale drawing of a section through the tear meridian is very helpful, but rest in bed or even a preliminary posterior sclerotomy drawing of subretinal fluid may bring the tear closer to its choroidal origin for a better localization, as well as render a previously hidden tear visible. Up to this stage it is easy to protect the cornea sufficiently so that with an electric ophthalmoscope (previously made ready with handle in a sterile towel) one may observe just how accurately the tracer micropin is placed in relation to the tear unless the tear is too far from the wall. If difficult to see, a longer pin may be used or the pin may be made to flash by contacting a wire extension from the eyelet to the stylus. So far, all the pins have been on white thread, serving a double purpose, one for treatment and the other for localization A barrage (often 2 dozen or more, 2 or 3 mm. apart) of black-threaded micropins is now set extending from the ora serrata around the tear, 2 to 4 mm. behind it and then back to the ora serrata again, thus secluding the tear area In using fine micropins it is usually well to put in a double-row staggered barrage and an especially thick (2 mm. apart) cluster of pins behind the tear

Arruga does his localization with a pair of dividers, with a centimeter rule, and with the Amsler indicator. His major localization is done at the operating table. He passes a thread at the limbus through the meridian where the rent is located, carrying this across and marking two points upon the sclera to indicate the meridian accurately. With the Amsler marking instrument he then outlines the distance between the rent and the limbus with his retractor and by transpupillary illumination. A spot of light appears on the sclera as it is directed through the hole to confirm his earlier measurements and to indicate the exact spot upon the sclera through which surgery is directed to seal the hole. This retractor has a curve at a right angle to its handle so that it will adjust itself to the scleral shell, and at an angle opposite to this it has a deep spherical curvature to furnish space for necessary instrumentation to the sclera, pushing the tissues away from the sclera and supplying satisfactory exposure.

The matter of localization by transillumination was first described by Weve[1] and, according to Jameson, used subsequently by Arruga and Šafář. In the latter part of 1934, Lindner also described this, but independently. Majewski's[2] recommendation for scleral transillumination to localize upon the sclera a retinal tear is delightfully simple, probably its best recommendation. The examiner locates the retinal tear with an ophthalmoscope, and then places a scleral lamp such as Lange's to the sclera at the point corresponding to the retinal tear, this being controlled by the ophthalmoscopic examination. The spot is marked upon the sclera with an indelible ink. Majewski does not hesitate to dissect the conjunctiva and underlying structures, if this is necessary, before applying the tip of the scleral lamp even prior to corrective surgery.

Recapitulation of Necessary Examinations.—As a review of examinations is necessary, the routine of Thorpe (H. E.)[3] is given here verbatim.

A Patient's history of ailment—duration and particulars, such as injury, myopia, ocular and systemic disease, etc.
  1. Sector of field where light flashes are first noted (also date of appearance).
  2 Sector of field where "cloud" or obscuration of vision is first noted and when first observed.

[1] Ann. d'ocul. January, 1934
[2] Arch. d'opht., 47, 440, 1930.
[3] Personal communication to the author

3. Appearance of vitreous opacities noted as "black specks" (due to *hemorrhage* or vitreous degeneration).
4. Date of obscuration of central vision.
5. Particulars of later sequence of events.

B. Examination proper.

1. Visual acuity and refraction.
2. Visual field examination.
3. Fundus examination with dilated pupil
   a. Ophthalmoscope with +1.00 sphere at ⅓ to ½ meter examining fundus reflex in all directions of gaze. Thus, the extent and location of the gray separation reflex is noted. Even tears can be seen and plotted
   b. Indirect and direct ophthalmoscopy in all directions of gaze determining details of the retinal separation, size, location, number and extent of retinal tears or holes as well as extent and location of degenerating cystic areas in retina. Whereas, the normal retina is a pink-orange color, being more pigmented in brunettes than in blonds, the separated retina is grayish. It is also elevated and appears in folds. Tears or holes in the separated area appear as sharply outlined reddish areas (vascular choroid reflex through pigment epithelium). At their margins the retina appears somewhat more gray and denser due to rolling or doubling of the edge Movements of the eye and changes of position of the body will often show up a tear in a retinal fold. Holes or tears may be round, irregular, horseshoe shaped. They may be single or multiple A hole may be 1/10 disc diameter or several disc diameters in size It is plotted in position according to the meridians or hours of the clock dial and according to its distance from the ora serrata in disc diameters It is also plotted according to the distance of its posterior border in angle degrees from the visual line. This is done by sighting along the arm of the hand perimeter while the patient's eye looks at the central fixation point (or his gaze is fixed so that a small light held at that point shows its corneal reflex in the pupil center) The size of the tear is noted in disc diameters or in degrees from border to border. Search for tears and degenerative changes in reapplied retina, in the cases in which the separation has shifted downward
   c. An accurate fundus sketch or diagram is to be made, noting details discovered, as well as the retinal elevation The angular location of the tear can be plotted on the scleral diagram by Stine's or Cowan's tables (see previous pages) from the measurements made with the ophthalmoscope and perimeter.
   d. Examination of fundus periphery with aid of 2 7 corneal contact lens. This obviates distortion by the periphery of the cornea and enables one to study the retina near the ora.
4. Measure intra-ocular tension It is usually lowered, but a coëxisting confusing glaucoma, with or without tumor, must not be overlooked.
5. Transilluminate globe to rule out possible presence of intra-ocular tumor
6. Subjective interpretation of retinal vessel shadows in the unseparated portion of retina (Purkinje phenomenon) is valuable when the vitreous is filled with blood preventing ophthalmoscopic study.

INDICATIONS AND CONTRAINDICATIONS FOR SURGERY IN TREATMENT OF RETINAL SEPARATION

The elimination of inoperable cases is a rather difficult matter. As most of these cases are hopeless without surgery, it is possible to operate unnecessarily and unwisely, hoping thereby to better the patient's unfortunate situation. A direct proportion exists between satisfactory reattachment and the length of time that the separation has existed. In older cases even though one may achieve a complete reattachment by means of an operation, the resulting visual acuity will quite likely be a great disappointment, as

the author stated.[1] Certain parts of this paper are included here in that they are relevant at this point.

Anatomically, it is known that detachment develops between the outermost layer of rods and cones and the epithelial layer of the retina, *i. e.*, in the layer of pigment epithelium. This region of separation is the space (if one can call it such) through which nourishment, by osmosis perhaps, normally reaches the outermost layers of the retina. It is possible that even in the presence of detachment these rods and cones continue to receive nourishment through this subretinal fluid, for in certain cases this fluid may be nothing but a transudate and pathological only mechanically by reason of its presence. If it were pathological in the inflammatory sense in all cases, the reason that recovery in some instances is so nearly complete, as observed grossly, is difficult to understand. At the same time, one can understand more readily the cause of failures. Microscopic sections of detached retinas seem to show that as long as a certain number of filaments lying between the cells of the pigment epithelium remain unbroken degenerative changes do not develop in the layer of rods and cones. Only after loss of continuity has occurred do the multiple changes appear that are so commonly observed in detached retinas of long standing. It is perhaps through this maintained integrity of structure that recovery of function can occur after reattachment, even when detachment has existed for an indefinite length of time.

Sallmann and Sveinsson[2] emphasized several requirements for preoperative conditions, which included a definite limit to the duration of the detachment, and they expressed the belief that vision less than that required for counting fingers renders the outlook hopeless from the start. Knapp,[3] in speaking of indications for surgery, presented at the same time certain contraindications.

Proper indications for operation must be present The most important indication is that the retina should be capable of being unraveled or replaced; it is also essential that no bands or folds be present and that the retina should not be shrunken; in other words, that none of the changes in the detached retina which come with age should have occurred. The color of the detached retina gives valuable information. The vitreous must not be disorganized and the tension of the eyeball not markedly reduced. This holds true particularly for aphakic cases.

Recently, an eye was studied microscopically after fairly successful reattachment with the classic Guist-Lindner technique. The patient died three months after surgery, in diabetic coma. Progressive retinal and choroidal degeneration was seen. Subretinal exudates and hæmorrhages were present to outline the limits of the detachment—in some places to a marked degree, and in others in such slight amounts that one could just see a thin line of exudate; in some areas with, and in others without, early changes in the layer of rods and cones. A few less definite changes were seen in the epithelial cells. The layer of rods and cones seemed to be the index of retinal viability. When these were not present as healthy looking elements, the other layers of the retina were also markedly impaired or even wholly wanting. Portions of the retina were changed to such a degree that one would have difficulty in identifying them as retinal tissue. The outer and inner nuclear layers, when normally present, were rather certain to be accompanied by a relatively normal-appearing layer of rods and cones. The destruction of one layer seemed to be accompanied by the loss of the others. In the light of the observations just mentioned, it is likely that the degree

[1] Spaeth: The Physiologic, Ophthalmoscopic and Microscopic Qualities of the Re-attached Retina, Arch. Ophth., 14, 715, 1935.
[2] Arch. f. Ophth., 130, 1, May, 1933.
[3] Arch. Ophth., vol. 10, No. 6, December, 1933.

of recovery in all its details depends largely upon the presence of healthy rods and cones and the absence of certain irregular subretinal cells, which probably are proliferated pigmented epithelial cells. The presence of cholesterol crystals is certain proof of extensive degeneration so marked that failure is certain.

The physiological tests give an almost sure estimation of the condition of the retinal elements, as they are concerned with the color fields and the threshold of light sense. The great loss which occurs in the color fields in cases of separation is generally recognized, the greatest being in the field for blue. One finds that the defect in the field for blue continues to exist to a varying extent even after ophthalmologically confirmed surgical cure. Further, the degree of recovery is not always proportionate to that seen in the peripheral form field, lost earlier, and to that of the gross central visual acuity. In the final analysis, both sensitivity of the peripheral form field and central visual acuity involve rather gross epicritic responses, and perfection in retinal details is not required for ready improvement in perception after successful surgical intervention.

Thorpe's rules[1] as to the rejection of cases for surgery follow herewith:

1. Separation due to toxemia of pregnancy unless holes are present in retina One case of separation (with retinal hole) during pregnancy was finally successfully reattached at the second operation. Three months later a full term, living baby arrived.
2. Cases of retinal separation due to intra-ocular tumor.
3. Cases of separation due to exudate in nephritis
4. Choroidal separation.
5. Total, gibbous separation that after a lapse of a few weeks shows no reduction with stenopaic spectacles or occlusion of both eyes
6. Very old separations with marked retinal degeneration
7. Funnel-shaped separations

NOTE.—Give all other cases the benefit of possible restoration of vision by operation.

In general, the presence of the following circumstances are contraindications to surgery; or if surgery is done, are rather likely the cause for failures Some of them may be correctable before the separation surgery is done.

1. **Posterior Synechiae** and 2. **Lens Changes.**—Cases with these present are the least satisfactory of all for surgery. They indicate with certainty the presence of a preëxisting uveitis. (This does not deny an ever likely relationship between uveitis and retinal separation.) The lens changes which are present in such instances are of the nature of a complicata, and the trauma connected with the surgery seems to hasten the maturation of the cataract to such a degree that beneficial effects from the surgery are wholly nullified. The question has arisen frequently as to the advisability of lens extraction in those cases of an immature complicata with multiple synechiæ as the result of retinal separation either untreated or unsuccessfully treated. The eyes are usually in hypertension, and in those few instances wherein this surgery has been carried out, the results were complete failures, with ultimate phthisis bulbi.

3. **Retinitis Proliferans.**—The separations of retinitis proliferans are probably the best example of the theory of tension. Draining the subretinal fluid will not destroy the tension of the bands which are tugging upon the retina. An attempt to section them has been suggested (Deutschmann),

[1] Personal communication

but the advisability of it, as well as the results which are to be obtained, are very much in doubt. In some cases of traumatic perforating injuries, retinitis proliferans develops at the ora serrata. Surgery is permissible in these cases, in that this area of peripheral retinitis can be sealed off entirely. There is a possibility of recurrences, however, in such instances.

4. **A Shadow.**—A shadow from or by transillumination, sufficient to make a diagnosis of intra-ocular neoplasm. (See section on Differential Diagnosis, also next paragraph.)

5. **The Absence of Any Subretinal Fluid** upon experimental subretinal puncture. This indicates organization of the transudates.

The organization of subretinal exudates, of transudates, and of subretinal hæmorrhages is responsible for an opaque shadow upon transillumination. There is no reason for operating in these instances. The theories upon which the surgery is based are unworkable in such cases.

6. **Grave Ocular Hypotension.**—It is rather likely that this degree of ocular hypotension is symptomatic of the basic iridocyclitis, and that the process is not quiescent. During the surgery for retinal separation, the eye undergoes further hypotension, and when this is added to the original hypotension, a flattened and collapsed eyeball develops so seriously injured that a cataracta complicata will certainly follow.

7. **Massive and Giant Lacerations** of the retina, and retinæ which are twisted and folded upon themselves, so often an accompaniment of giant tears, and distorted to such a degree that it is quite impossible even to imagine a probable cure, can be spared the pain, distress, and expense of surgery, for these cases are usually hopeless from the start.

8. **The Duration of the Separation,** its etiological factor, especially the consideration of traumatisms and of perforating wounds are all factors which must be considered in deciding upon the advisability of surgery in any one case.

9. **With Neoplasms and With Retinal Cysts,** surgery is naturally contraindicated, in that the separation in these instances is purely symptomatic. The problem here is only one of differential diagnosis—one not always simple.

10. **Aphakia is Not a Contraindication** to surgery, *per se*. A retinal separation, if already complicated by capsule and cortex remnants, is not necessarily hopeless. The sequence of operations should be the discission or capsulotomy first and the surgery for the retinal separation thereafter. Gifford[1] spoke of this relationship which aphakia bears to detachment, insisting on the necessity of separating retinal separation and aphakia into two general subdivisions. He said:

> A distinction must be made, however, between detachment occurring immediately after operation for cataract with loss of vitreous, in which the media are cloudy and the eye is always soft, and detachment occurring some time after extraction of the lens, with clear media. In the former condition good results are practically never obtained, while in the latter an appreciable number of good results are recorded In my series (Gifford) there were four cases of aphakia and one of dislocation of the lens; in three of these good results were obtained. To this must be added one case in which an excellent result followed ignipuncture.

11. **Retinal Separation** in the presence of diabetes is oftentimes complicated by vitreous hæmorrhages which seem to be greater in degree and

[1] Arch. Ophth., 16, 3, September, 1936.

more frequent in occurrence than in non-diabetic cases. Vitreous opacities also seem to develop more frequently, though fortunately they may become absorbed.

12. **The Symptomatic Separation of Nephritis** and of the nephritic toxemias of pregnancy are not satisfactory cases for surgery, usually because of the patient's general physical condition. In these instances, with nephritis, the problem of saving the patient's life is a far more important one than that of conserving the vision. Further, these are the only cases which give any percentage of spontaneous non-operative recoveries. The retinal separation of the toxemias of pregnancy call, not for surgery to the eye, but for the termination of the pregnancy. Following this, if such separations fail to recover, then surgery may be considered. In speaking of these cases, Anderson feels the longer the interval between the onset of the retinal separation and the termination of the pregnancy, the smaller the chances of spontaneous recovery.

13. **A Complete Separation of the Retina** is a contraindication to immediate surgery. If any percentage of spontaneous recovery can be achieved by non-surgical methods the prognosis is immediately much better, and surgery may be considered more seriously.

14. **Post-traumatic Retinal Separation** with the presence of a retained intra-ocular foreign body need not be operated for the retinal separation unless the foreign body can be first removed. The importance of this lies in the careful examination of all eyes which have had perforating injuries. Radio-opaque foreign bodies can be readily diagnosed. Those, however, which are not opaque to roentgen-ray are not as easily found.

Gonin's indications and contraindications for operability and inoperability in any case, given by Schoenberg[1] in discussing the Gonin ignipuncture operation, is as follows:

> The indications that would stamp a case as operable are: (1) A detachment of relatively short duration (at the most, from two to three months), the shorter the age of the detachment, the more definite is the indication. (2) The small number of retinal tears, their small size and their location in an accessible area. (3) A relatively normal looking vitreous, iris and retina.
>
> The operative contraindications are: (1) A detachment of long duration or a total detachment even of short duration. (2) The absence of a tear or the presence of a very large tear, principally at the ora serrata (retinal dialysis). (3) Cloudy media interfering with proper ophthalmoscopy. (4) A greatly degenerated vitreous and retina and active iridocyclitis.

[1] Arch. Ophth., vol. 6, No. 5, November, 1931.

CHAPTER XXV

THE SURGICAL TREATMENT OF RETINAL SEPARATION

The treatment of retinal separation can be divided into a presurgical phase, a surgical or operative phase, and the postoperative or postsurgical handling of the case.

PRESURGICAL MEASURES

A word as to prophylaxis is quite proper at this time. It has to do wholly with the handling of myopia. Stallard[1] quotes Nordenson's statistics in a series of 1100 cases with spontaneous separation of the retina; 80 per cent were myopes, and of these over 50 per cent were over fifty years of age. The handling of myopia in patients of school age is a problem of ocular hygiene and need not be reviewed at this time. Every ophthalmologist has seen cases swing from hyperopia through to myopia; and in many instances arrestment of the myopia has been achieved after the patient has been taken from school and compelled to abstain from all near work. Grunert's[2] system of treating myopia with pilocarpin is, as Anderson says, well worth the trial. Of 399 cases of myopia of less than 6 diopters, 54 per cent were progressive when not treated with pilocarpin, whereas amongst 53 with a corresponding degree of myopia, 41.5 per cent were progressive when treated. Of 99 patients with from 6 to 12 diopters, 54.5 per cent advanced when not treated, compared with 8 per cent of a series of 26 who were treated. Of 38 myopes of from 12 diopters up, 91 per cent advanced without treatment but only 6.6 per cent of 60 patients did so when treated with pilocarpin. Grunert has given up Fukala's operation (removal of the lens), repeated paracentesis, and subconjunctival injections. Birch-Hirschfeld[3] considered the artificial interruption of pregnancy for high-grade myopia as a point of importance. He considers this indicated if one eye is seriously affected by myopic degeneration and definite changes are present in the other. Relative to this, a wise course to adopt in pregnancy, after successful surgery of a separation, will depend on the state of the other eye.

As soon as the diagnosis of separation has been made, the patient must be hospitalized and treated as a strict bed patient. Pin-hole glasses should be ordered forthwith even before the surgery and must be worn at all times. In traumatic separations which are so frequently complicated by vitreous hæmorrhage and by contusio bulbi, surgery should be delayed for a period of rest in bed, for atropinization, and for moderate dehydration of the patient, permitting at the same time the contused tissues to return to a more nearly normal state of health. Even if the tear is found at the first examination, this period of preliminary rest is indicated. Non-traumatic cases have a rather similar relationship to rest in bed, though in these, surgery may be carried out soon after the retinal tear has been discovered. The degree of spontaneous absorption of the subretinal fluids which will occur is remarkable in some patients who are given this period of rest prior to surgery. This also applies to the retinal separation occasionally seen early

[1] Brit. Jour. Ophth., 14, 11, 1930.
[2] Klin. Monatsbl. f. Augenh., 80, 522, 1928.
[3] Ztschr. f. Augenh., 68, 127, 1929.

after cataract surgery. This is not to include cases of choroidal detachment. In those cases wherein a tear cannot be found, surgery must not be carried out until all means for finding the tear have been exhausted. These various procedures include rest in bed, dehydration, the limitation of fluid intake, the continued wearing of pin-hole glasses, transillumination, and any necessary preliminary subretinal drainage.

Mercury, iodides, sodium salicylates, and thyroid extract, have all been recommended as of value during this period of preoperative observation. A compression bandage with pressure upon the eyeball was used for a long time, but the pin-hole glasses, quieting thereby ocular movements, and the subsequent stress and strain upon the vitreous, are much more logical. The diabetic patient must be standardized, and the patient with nephritis must be treated from that standpoint. Calcium salts may be given preoperatively, in that they probably do lessen the tendency to hæmorrhage, and may as Anderson said, play a part in lessening a tendency to effusion from a hyperemic choroid.

Gradle[1] in discussing detachment of the retina spoke about the necessary preoperative immobilization in these cases. His recapitulations are rather interesting.

> The more rapid and the more extensive the flattening of the retina under immobilization the better is the prognosis of the proposed surgical tract. The flatter the retina becomes under immobilization the more accurate is the localization of the hole in its final position. The less fluid there is under the retina at the time of operation, the less extensive need be the surgical attack upon the sclera The better the approximation of the retina to the choroid, the better are the chances for postoperative firm adhesions, and the less chances of the recurrences of the detachment.

It is no wonder that a period of five to ten days of preoperative immobilization is not considered wasted time in terms of final result in these cases.

Thorpe's rules[2] as he carries them out for preoperative procedures follow herewith:

Management of case previous to operation—admit patient to hospital at once

1. Stenopaic, round-hole spectacles should be immediately applied Rotations of the globe are responsible for increase in separation or its shifting. Occlusive bilateral dressing may take the place of above spectacles.
2. Confinement to bed is not essential previous to surgery.
3. Examine the case daily with patient in sitting and recumbent positions until sure that holes and degenerated retina are carefully plotted Take anywhere from two to ten days, if unsuccessful in finding the retinal hole at first
4. Aspirate subretinal fluid with hypodermic syringe only when necessary. It may help to find a tear. Be careful not to make a new retinal hole with the hypodermic needle.
5. Make careful physical and laboratory studies during preparatory period. But do not delay the operation unduly by such studies. Do all the studies in the hospital. Remember that sealing off the retinal hole and creating adhesions between retina and choroid in this area and adequate drainage of subretinal fluid are the first essentials for successful treatment.
6. Dilate pupil with atropine preoperatively.

SURGICAL TREATMENT OF RETINAL SEPARATION

The surgery of retinal separation at the present time still properly maintains various theories and apparent necessities which have been a consider-

[1] Am. Jour. Ophth., Lancaster Testimonial Issue, Series 3, No. 5, May, 1943.

[2] Personal communication.

separation, however, as a complication of pregnancy, needs more than termination of labor for recovery. The vitreous and retinal pathology of diabetes is probably best treated by some form of non-perforating therapy, as are the flat detachments after aphakia.

Considering the above generalizations, we must include in our armamentarium the following surgical procedures and use them when indicated: (1) Thermocautery; (2) scleral trephining and chemical cauterization; (3) surface therapy; (4) perforating anode-diathermy needles; (5) catholysis; (6) scleral shortening. All have specific indications, and must be utilized to their fullest possibilities when those indications are present in the individual under consideration.

situations possible. Further, it is childish to repeat that statement recently made: "that there are so many different operations for retinal separation because all are unsatisfactory." The truth of the matter is there are so many different individual complexes, and each needs special consideration. Even the etiology modifies the surgical demands. For instance, a traumatic separation from a perforating wound is to be treated differently than one from a non-perforating wound; in these instances, the traumatism being a force applied directly to the eyeball.

Etiologically, basically, but essentially from a surgical standpoint, the four possible mechanisms entering into the development of retinal separation, must be considered in the treatment of a case. They all play, probably, equally important rôles, though under varying circumstances, each peculiar to an individual case.

The theories (surgically speaking) in question are not new. Some of them have been discussed as far back as 1887, when Nordensen argued the importance of the attraction theory versus the distension theory. In so far as a theory of exudation is concerned, Graefe, in 1885, discussed this expressing an opinion for the cause of "subchoroidal hydrops with retinal detachment" found after enucleation. (This was before the days of the ophthalmoscope.) The fourth theory, that of distension, was under consideration when Müller recommended a scleral resection for a separated retina in 1858.

In operating minimal and flat separations, one must be careful not to make new retinal holes and thus defeat the surgical procedures which are being carried out. Conversely, in operating large bullous separations, subretinal drainage is absolutely necessary before any operative adhesive choroiditis can function for a cure of the case. A disinsertion must be closed off, and in doing it, the ciliary body and pars ciliaris of the retina cannot be traumatized. A minimal separation with a demonstrable hole still stands as the best indication for the original Gonin thermocautery operation. If the hole cannot be found (and it is safe to assume that retinal holes are present in 100 per cent of instances), one must know his case sufficiently well to be able to say "the hole should be in this region," and the surgical treatment must be carried out at that point as if a hole was actually seen and mapped out. Traumatic separations from non-perforating wounds frequently have huge tears, at times with the retina actually rolled up upon itself as one can roll the page of an open book. Unless these leaves are flattened out and the edge of the tear surgically segregated from the contiguous retina, the eye is certainly lost. Bullous separations frequently need subretinal drainage by a scleral paracentesis for adequate presurgical diagnosis. A hole in the macula can be handled in several ways, but unless the separation is replaced with the least amount of damage to the retina, the surgery will not improve the central vision. Lindner's technique of posterior sclerotomy, extrachoroidal tunneling, and the use of potassium hydroxide is an almost necessary procedure here. Separations with glaucoma need a posterior scleral fistulization procedure. Aphakia of itself should not modify the percentage of successes or failures. Circumstances, however, connected with the aphakia, are the important factors.

Retinal separation with nephritis is probably not an operative situation. Hypotony when present to a marked degree demands some form of surgery, as surface therapy, other than penetrating diathermy punctures. Retinal

separation, however, as a complication of pregnancy, needs more than termination of labor for recovery. The vitreous and retinal pathology of diabetes is probably best treated by some form of non-perforating therapy, as are the flat detachments after aphakia.

Considering the above generalizations, we must include in our armamentarium the following surgical procedures and use them when indicated: (1) Thermocautery; (2) scleral trephining and chemical cauterization; (3) surface therapy; (4) perforating anode-diathermy needles; (5) catholysis; (6) scleral shortening. All have specific indications, and must be utilized to their fullest possibilities when those indications are present in the individual under consideration.

1. **Minimal Separations Without a Demonstrable Hole or a Disinsertion** are to be treated by a procedure which will probably seal the undiscovered rent and at the same time do least damage to the barely elevated retina or to that retina which is only in a flat separation. For this reason the surgery possible with an electrode similar to the Lacarrère or Weve type is probably most applicable and most readily carried out. The use of Walker needles and the Šafář nails is probably equally as applicable.

2 **Cases of Minimal Separation With a Demonstrable Hole** are to be operated by any procedure which will satisfactorily localize the hole and seal it. For this reason the Walker needles, the adjustable electrodes, and the use of a negative galvanic current, *i. e.*, catholysis, are especially applicable. Gonin's thermo-cautery has its best applications here.

3. **Retinal Separation, With a Disinsertion**, can be treated as mentioned above for 2, if the degree of separation is minimal in amount. The Walker needles, and scleral trephining are very satisfactory for rimming the disinsertion. The adjustable electrodes of Weve and of Lacarrère are equally as applicable. If the extent of the accompanying separation is considerable, the longer needles of Walker and the electrodes of Walker, Meesmann, of Weve, and of Coppez can be used to advantage.

4. **Pure Traumatic Separations From Perforating Wounds** are fortunately not great in extent when the diagnosis can be made early. Because of the late development of a proliferating retinitis which so commonly follows perforating wounds, one must hope for early diagnosis and insist on prophylactic treatment in these instances. The essential factor is a sealing of the hole. The Walker and Šafář needles, and Walker's and Vogt's, von Szily's and Machmer's system of catholysis should be satisfactory here.

5. **Cases of Traumatic Separation From Non-perforating Wounds**, *i. e.*, those cases of gross traumatisms and with giant tears, are at best unsatisfactory cases. The Weve and Meesmann needles are necessary for an accurate delimitation of the tear. This then, should be rimmed about with catholysis and the remaining portion of the separation treated by a procedure which will maintain as much of the ocular tension as is possible until the operation is completed. This would limit the surgery almost wholly to the use of the Walker and Šafář electrodes and needles.

6. **Large Bullous Separations, With and Without Demonstrable Tears** but involving less than one-half of the retina must be subdivided into superior and inferior separations, because of the greater scleral exposure which is possible for the inferior sclera. Scleral trephining, the Walker and the Šafář electrodes, and surface coagulation can be combined with the longer electrodes or catholysis for localization of tears and for their closure. The

difficulty of obtaining equally satisfactory exposure to the superior portion of the sclera limits the advantages of scleral trephining above.

The statement just made relative to paragraph 6 applies herein, except that in those instances it will be necessary to operate more than once to cover the entire field. If the retinal tear is above, the surgery should be applied to this first, in detail. At the same time, one may use the longer electrodes below, though sparingly, hoping, thereby, to decrease in amount or degree the subsequent surgery necessary. If the retinal tear or tears are below in the fundus, it is probably wiser to pay attention to this half of the fundus and operate above subsequently by surface coagulation with the drainage necessary. In these cases of massive separation the localizing value of the longer electrodes and the benefits of catholysis must be seriously considered and utilized whenever possible.

7. **Cases of Retinal Separation With a Hole at the Macula** can be advantageously treated by the adjustable electrodes of Lacarrère, of Walker, and of Weve. Catholysis is of equal value. The anatomical difficulties connected with the implantation of the smaller micropins of Walker and of Šafář make the use of these a bit difficult. The minimal amount of drainage which is necessary and the consequent softening of the globe during surgery are minimal in significance when using the adjustable electrodes previously mentioned. The subchoroidal undermining methods of Lindner and of Walker have given these cases good results in the hands of both of these operators. If these cases are also accompanied by extensive peripheral separation then the surgery which is applied to the macula may be combined with these procedures mentioned under paragraphs 6 and 7.

8. **Cases of Retinal Separation With Aphakia** seem to respond best to the use of surface coagulation plus drainage. Tears and disinsertions, when found, may be sealed last at the operation with the small electrodes of Walker and of Šafář, but probably the longer electrodes and those adjustable as in the case of Weve's and Lacarrère's, or those of Meesmann are better. Catholysis should also lend itself beautifully in these instances

9. **Retinal Separation of Nephritis** is probably not a surgical condition unless the patient's general physical condition can be so improved that he has become thereby a fair operative risk. Pregnancy when accompanied or when complicated by retinal separation should first be terminated by induced labor, hysterotomy or hysterectomy, depending upon other circumstances and conditions present in the case. These cases when operable ophthalmologically are to be handled as was discussed above in 6 and 7.

10. **Retinal Separation With Diabetes** and with other definite subacute and chronic chorio-retinitic processes are to be operated by a technique which results in the least amount of undesired and permanent damage to the choroid, retina and the vitreous. One means of preventing such undesirable damage is to maintain the tension of the eyeball during the operation and when obtaining subretinal drainage. The amount of vitreous damage controls the subsequent amount of vitreous opacities which develop postoperatively. There is no doubt that the retinal tears must be sealed satisfactorily; therefore, the means for this are the same as those discussed under 6 and 7 above. In addition to those procedures, the micropin of Walker and the nails of Šafář are to be considered first, and surface coagulation secondly. These cases, as in all vascular states, must have metic-

ulous attention to the vortex veins so that no damage whatsoever is done to them.

The surgery for retinal separation even under the best of circumstances cannot give 100 per cent of successes. A statement, however, was made by the author in discussing a paper on retinal separation[1] that, with constant improvement in technique, and with the development of new technique, we are rapidly approaching a time when we may reasonably expect the same percentage of recoveries in this condition that we expect and obtain from the surgery of cataract extraction.

Rather recently, Lindner seriously considered a renaissance of Müller's original surgery, discussed by Török in 1917, and by Koch somewhat later. Müller failed to repeat successfully Deutschmann's operation,[2] and he advocated a new procedure based on the same theory. Müller, finding it impossible to bring the retina into contact with the choroid by division of the vitreous strands, attempted to bring the choroid in towards the displaced retina by removing a portion of the sclera. The technique is difficult and the risk of hæmorrhage and of vitreous loss considerable. By so reducing the volume of the eyeball, he hoped to establish adhesions between the two retinal layers, and so restore the function of the rods and cones. Though some success attended this method, it is never done now. Török stated, in 1917, that in the previous twenty-five years only about 50 operations had been reported. He had performed it on 21 patients, but could claim no permanent cures. Koch in 1927 used this method for 18 patients, and obtained 1 complete and permanent cure, and improvement in 6 others.

The matter of the retinal tear and the handling of this was the threshold which Gonin crossed in ushering in modern surgery for these conditions. These two together, therefore—the handling of the retinal tear and the attempt to reduce the capacity of the globe—when taken with the modern methods of obtaining permanent drainage, are the factors making possible successful surgery and together are the *sine qua non* of further surgical research in this field.

The surgical measures recommended for reducing the capacity of the globe have been discussed under scleral surgery. The consideration of the remaining two follows. The provision for obtaining drainage was first recommended, as has been stated, by de Wecker in 1872. Practically nothing was done in this field until Elliot presented his operation of corneoscleral trephining for glaucoma. It was quite remarkable that this therapy did result in many recoveries. Ohm[3] reported 2 cures in a series of 7 patients. Thomson and Curtin[4] reported 7 cures, though they aspirated at the time of trephining. Chipman[5] reported 1 cure. Several other men reported good results and felt that it had some value. Parker[6] reported 15 trephinings with 4 improvements. MacCallan[7] also thought it to be of value. Groenholm,[8] Meller,[9] and Sloan[10] found some improvement and

[1] Baer and Shipman The Results of Retinal Detachment, New Jersey State Medical Society, Atlantic City, April, 1936

[2] Klin Monatsbl f Augenh., 51, 762, 1895. [3] Deutsch med Wchnschr., 43, 748, 1919

[4] Jour. Am Med. Assn., p 330, April, 1916.

[5] Canad. Med. Assn. Jour., 10, 1007, 1921.

[6] Sec. Ophth., Am. Med. Assn., vol. 106, 1915.

[7] Am. Jour Ophth., 9, 455, 1926. [8] Arch. f. Ophth., 105, 899, 1923.

[9] Ophth. Surgery, 3d ed., transl. by Sweet, p. 311, 1923, P. Blakiston's Son & Company, Philadelphia.

[10] South. Med Jour., vol. 228, 1926.

reported some cures utilizing their filtration procedures, especially choroidodialysis and Holth's pre-equatorial sclerectomy.

Guist and Lindner,[1] in their surgery for retinal separation, utilize multiple scleral trephining openings and by the application of potassium hydroxide obtain not only adhesions through their surgery, but also the establishment of permanent drainage. The manner in which a retinal tear was rimmed with their trephine openings and the subsequent results which they obtained in sealing such tears, demonstrates beyond a doubt not only the satisfactory achievement of these two principles but also, as conclusively, the necessity for them. Lindner's[2] subretinal tunneling of the choroid from the sclera, which will be described later, and the injection of a 6 per cent solution of potassium hydroxide into this suprachoroidal space, is a further modification of scleral trephining combining certain choroidal adhesions with drainage. The drainage obtained by diathermy coagulation and by catholysis is undoubtedly a simpler procedure, lasts equally as long as that obtained through the scleral trephining openings, and the number of *scleral punctures which is possible probably offsets* the greater amount of drainage obtained through the fewer scleral trephining openings. These close promptly, but they can be made to cover a very large area, and one can rim a giant tear or a small tear with them quite readily. They do cause considerable cicatrix, as any one will state who has been compelled to reoperate after a scleral trephining technique has been done previously.

In addition to the drainage obtained by the microcautery needles of Walker, there are the nails of Šafář; the electrodes of Gonin, of Meesmann, von Szily and Machemer, of Lacarrère, of Weve, of Coppez, and of Vogt, (regardless of whether catholysis is being used, galvanism, diathermy, cautery or electrocautery of the trephinings of Lindner and Guist), and it is occasionally necessary to augment the drainage by further perforation of the sclera. A cataract knife or the triangular lancet of Arruga is satisfactory. This latter is especially fine for orienting oneself during an operation in the further localization of retinal tears. Walker[3] is quoted at length relative to drainage:

> The real question is concerning sufficient drainage of subretinal fluid, without, it seems to me, allowing any more drainage than is possible immediately over the tear where good vitreous is liable to be obtainable. For instance, I would not put a large pyramidal microtip or a quill tip of a trephine directly over the tear These devices should be scattered in a minor barrage around the tear, but inside the outer barrage already described, until one feels sure that sufficient drainage has been provided. On the other hand, if ignipuncture is combined with the operation, as can successfully be done, then I believe in putting a fine (½ mm) white hot electro-cautery with a very steady hand directly and quickly into the tear and slowly out again without loss of white heat if possible because thereby the vitreous plug in the tear is so cauterized that it is condensed and does not have a tendency to herniate in globular form, notable in similar large drainage openings by other methods. Only thin, slightly yellowish subretinal fluid without much stringy tendency comes from the favorable procedures. A preliminary pathway for the ignipuncture is prepared by three fine micropin punctures forming a bloodless line over the tear through which a cataract knife first is entered to reduce the work of the white-hot point. However, the addition of the ignipuncture procedure almost doubles the necessary equipment and is not without certain disagreeable sequelæ,

[1] Ztschr. f. Augenh, 74, 232, 1930; Klin Monatsbl f Augenh, 90, 771, 1930, Albrecht von Graefe's Arch. f. Ophth., Sondaus, vol 127, Pts. 2, 3 1931.

[2] Klin Monatsbl f Augenh., 90, 246, 1933

[3] Am. Jour. Ophth., vol 17, No 1, January, 1934.

even though these may be greatly reduced by the action of the encircling barrage. If the ignipuncture is not added, as it has not been lately, then after both barrages of fine and heavy pins are set, the area over the tear is further treated either with a cluster of fine pins, or quicker and better, with beading-needles, slanting micropunctures aimed to pass between choroid and sclera following the pattern of the tear. Finally the duration of the drainage is further aided by the use of the quill tip placed at the two to four locations in or near the inner barrage. This gives a bloodless drainage, smaller than an ignipuncture or trephine in size, but larger than a low-amperage, conical or pyramidal pin-puncture. With this quill one may proceed more deliberately and as each one is inserted, the tiny leakage gives one a definite idea of what drainage may be expected at that point; especially if it is in a pocket region of clear subretinal fluid will it give the proper clue, and still close the opening if it is desirable to make more similar openings on other sides of the tear It is used only for bullous elevations.

Drainage continues postoperatively for quite some time after the operation. It is doubtful whether any of the subretinal fluid disappears through absorption, except rather late in the postoperative convalescence. Everyone has seen a slight delay in complete postoperative flattening long after further trans-scleral drainage is possible. In spite of this, these cases do achieve a complete recovery, and it must have occurred by terminal absorption of the residual subretinal fluid. Early in the surgery of retinal separations, there was some controversy as to the application of pressure bandages to augment drainage. It is doubtful whether this is necessary, and in fact, it may be unwise. A resilient ring of cotton had better be placed above the simple postoperative dressing and the immediate postoperative drainage assisted by a position in bed utilizing gravity, *i. e.*, with the head up or back, to the right or to the left.

Handling of the Tear.—The tear must be sealed, otherwise the surgery will not be successful. This fact stands in spite of the fact that occasionally cases are operated, with success, wherein no tear had been found. The incidence of success in these instances is definitely lower according to all observers. The well presented series of Baer and Shipman[1] showed only 7.5 per cent of failures in those cases with tears as compared with 34 per cent of failures in those cases in which no tears were found, illustrating beautifully this relationship which tears play to successes with surgery. It is of equal importance to abstain from causing new retinal holes during the surgery by the unwise and inadvertent diathermy puncture of intact retina. This point will be mentioned again. Ideal surgery, *i. e.*, to seal the tears with a minimum amount of subsequent necessary scleral perforations, these to permit adequate drainage, is only possible when a tear can be localized. Failing this, it will be necessary to cover the entire field of separation, from the ora to the periphery of the separation, hoping thereby that the hole will be sealed by this extensive diathermy coagulation. In addition to these efforts, on the operating table one must utilize ophthalmoscopic search to further try for localization of the tear. One or two scleral micropin punctures may permit sufficient subretinal drainage so that, as the folds are ironed out and the bullous and gibbous separations decreased in degree, tears which were formerly hidden will appear.

The aids in accurately localizing tears are varied and under certain individual circumstances are individually valuable. Occasions will arise undoubtedly, where each would apply most advantageously. Transpupil-

[1] Pennsylvania Med. Jour., April, 1935; Trans Ophth. Sect. of New Jersey State Med. Soc., April 18, 1936

lary illumination will permit accurate marking, upon the sclera, of a spot of light from the beam which passes through the tear. This is, however, not always sufficient. Arruga's triangular lancet, which has a broad round base and a little nob above this, for convenient handling with forceps, can be introduced right into the center of this spot of light and its intra-ocular position then checked with an ophthalmoscope. Weve's needles or one or more of the longer electrodes, as of Meesmann's, can be introduced as well, also for localization. It is quite possible to do the same thing with Walker's needles or with Šafář's nails. Bubbles of gas will appear at the tips of the electrodes when using catholysis. Catholysis, according to the technique of Vogt or of Walker, with the cathode or the negative pole in the shape of a fine needle, will give bubbles of hydrogen at the site of the perforation, and even though the electrode cannot be seen with the ophthalmoscope, one can see this little cluster of gas bubbles. The positive pole, or the anode, if it is used for perforation, also causes gas bubbles, but of oxygen. As a matter of fact, Walker in his surgery and in his presentation of his latest apparatus, before the Section of Ophthalmology, American Medical Association, June 11, 1937, spoke of the value of utilizing these anode bubbles of nascent oxygen for neutralizing the inevitable alkalinity resulting from extensive catholysis.

SURGERY OF RETINAL SEPARATION

Anesthesia.—Individual cases must be handled differently, depending upon the age of the patient, his or her disposition and temperament, and the probable length of time that the surgical procedures will consume Necessary reoperations are always dreaded by the patient, and this fact will modify the anesthesia as well. The experiences of the various operators and writers are varied. Walker, Arruga, Weve, Baer, and Shipman, and many others, operate largely under local anesthesia. Avertin anesthesia should be used more commonly. All men undoubtedly do best work when the anesthetic is selected for a patient after careful consideration. For local anesthesia one should use 0.5 to 1 per cent of pontocain to prevent desiccation of the corneal epithelium. The conjunctiva may then be lifted with a 0.5 per cent novocain solution, the muscle sheaths injected as well, with the same solution, the skin of the external canthal angle also injected, and a 1 per cent novocain solution used for retrobulbar injection, without adrenalin, in that the addition of adrenalin causes hypotension If avertin anesthesia is used, it can be augmented by the retrobulbar injection and the subconjunctival injections, as well, giving a very satisfactory anesthesia with a minimal amount of avertin. Instances arise during longer operations where venethene must be used as an adjunct, in addition to the above.

Surgery.—The surgery in general may be divided into four general subdivisions or types of operative procedures; the first applies to all the subdivisions, and 2, 3, and 4, can be used singly or in combinations.

1. Sealing the retinal tears (see previous instructions and page 811). This is of special and essential importance in traumatic perforation of the globe, but without retention of the missile, and in foreign bodies (intraocular) which have been removed from the vitreous chamber by a posterior sclerotomy. (2) Scleral trephinings, with drainage. (3) Surface scleral therapy with drainage added, as the application of the thermophore, the

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pyrometric apparatus of Coppez, and the ball electrode of Larsson. (4) Scleral penetration. This includes Gonin's thermo-cautery; Šafář's, Walker's, Meesmann's, and Weve's micropin electrodes, the electrodes of Lacarrère and of Coppez, the cathode electrolysis of Vogt, of Walker, of von Szily, and of Machemer.

Sealing a retinal laceration is a procedure which should be carried out as prophylaxis in the presence of all perforating wounds of the sclera when the point of entrance is posterior to the ora serrata, regardless of whether the missile or the penetrating instrument has neen removed from the eye or is being removed from the eye either by posterior sclerotomy or through an anterior route. After cleansing of the wound and any necessary débridement, the area of the scleral perforation is rimmed about with a series of Walker's small micro-cautery needles. One may use also Meesmann's or Weve's needles, or the diathermy cautery of Lacarrère. As soon as this is completed, any necessary scleral sutures are to be introduced and the conjunctiva closed. These cases do not need the stringent postoperative procedures necessary for the surgery of retinal separation, but they should have binocular dressings and absolute rest for eight to ten days after the surgery. In some of them it will be necessary to order pin-hole glasses for a varying length of time and even frosted spectacles with a 1 centimeter clear central aperture.

The field of exposure in all forms of retinal separation surgery should be as extensive as is possible. Conjunctival and capsule incisions must never be limited. A wide exposure heals as readily as a small one. An external angle canthotomy is necessary in the largest percentage of instances. This can be closed with sutures at the end of the operation without difficulty. Muscle resections permit a greater amount of rotations for adequate treatment, and they *do not tend* toward subsequent deviations from parallelism if properly reattached. The field of operation must be kept dry to allow satisfactory electrolysis. At the same time, however, the operator must be very particular to prevent drying of the cornea, for this interferes with ophthalmoscopy; a procedure frequently necessary and often desirable during an operation.

Scleral Trephining.—Practically all cases for retinal separation surgery need an external canthotomy to permit satisfactory exposure. This should be closed with sutures to stop bleeding, usually before the speculum is introduced. Guist's speculum is very satisfactory in that it permits a maximum dilation of the palpebral fissure, and at the same time, by means of the adjustable legs, it raises the lids from the globe allowing even fuller deep exposure. The conjunctiva is incised over the site of the separation and the recti muscles, which must be severed, are lifted upon a strabismus hook. A whip-stitch, double-armed suture, No. 1 black braided silk, is passed through the edges of these muscles, the muscles dissected free from the sclera, close to their attachments, and laid back out of the way. Tiny artery clips may be used on the two ends of these sutures to prevent confusion and to permit easy identification. A second similar suture is passed twice through the stump and the needle removed; this to be used as a traction suture. If Walker's needles with their attached black silk threads are being used for the surgery, it is wise to make these traction sutures of white silk to eliminate confusion. The sclera is then cleansed and bared over the site of the separation and over that area at which the hole or the disinsertion has been localized. A 1 mm., or at the most $1\frac{1}{2}$ mm., Elliot trephine blade

and handle are used, (Lindner used a 1.75 mm. blade) or some similar clock-driven mechanical trephine. It is most important to prevent perforation of the sclera and injury to the underlying choroid. For this reason, the trephining should be done very carefully, withdrawing the trephine frequently to observe the depth of penetration which has been achieved. The trephine should be held perpendicular to the sclera and such attention paid that the vortex veins are not injured. As soon as the black color of the choroid appears in the circular cut of the trephine, further cutting should cease at that point and the operator proceed to the next one planned. Trephine holes should encircle the tear or tears present and should rim about rents and disinsertions at the ora serrata. As soon as the number and position of trephinings has been made, each of the disks is removed by grasping it with fine conjunctival forceps and cutting it free with fine sharp-pointed scissors. If the choroid becomes perforated at this time, or previously, the hole should be plugged immediately with one of Arruga's screw plugs. These have a flat shoulder to prevent them from passing into the eye, and a square lug fitting into a handle so that they can be screwed directly into the hole. They are tiny and as many as are necessary can be used in any one case. When all the trephine openings have been made and the disks resected, the choroid presenting in each of them is touched with a tip of a pencil of potassium hydroxide, the alkali being held there for about one-half minute and immediately thereafter neutralized with a loosely wound cotton applicator saturated with 0.5 per cent acetic acid. The application of the caustic may be a bit painful; therefore, before it is applied, the scleral area about the presenting choroid should be touched with a cotton wound applicator wet with a 10 per cent solution of cocain. The two chemicals are then washed from the cul-de-sac by copious irrigations of warm saline solution; each trephine opening, one after the other, is treated in this manner. After they have been all treated, additional irrigation with normal saline is used to be sure that none of the chemicals are still present A blunt-pointed instrument is then used to perforate the choroid at all of the trephine openings about the tear and a sufficient number of the others to guarantee adequate drainage. In some instances, all will have to be opened, in others a lesser number. The choroid can be perforated with a strabismus hook as Arruga recommended, or, as the author does, with a canaliculus dilator. The size and the tip of this instrument are very satisfactory for this perforation.

In carrying out this technique, a logical plan is to place the trephining holes first about the retinal tear, thereafter to outline the limits of the separation with a line of trephinings and to then place subsequent ones in between as is necessary, depending upon the area of the retina which has been separated. A sharp trephine blade must be used, and because the sclera varies in thickness at various places, one must proceed very slowly. Figure 495 is a case showing 7 trephining openings surrounding a disinsertion below, beneath the insertion of the inferior rectus with 9 other trephining openings outlining the separation, back 21 mm. from the limbus, *i. e.*, the separation in this instance extended 5 to 6 mm. in back of the equator to about 10 mm. from the macula.

The traction suture is removed from the stump of the muscle or muscles detached, the muscle sutures themselves passed through the stump, the superficial sclera, and out through the juxtalimbal lip of the conjunctiva. These are pulled up into position, tied, and their ends cut short. The con-

junctiva is then closed, either with interrupted sutures or with a running suture as one wishes. It is important, regardless of the type of suture used, that the detached and retracted Tenon's capsule also be closed with the conjunctiva. The cul-de-sac is again irrigated to cleanse it from any clots or retained chemicals, atropine instilled as an ointment, and the postoperative dressing applied.

Black[1] has had a rather extensive experience in the use of the Lindner-Guist technique for retinal separation. He stated the four essential stages in the procedure to be: (1) the choice of the case; (2) the preparation of the case and localization of the hole; (3) the planning of the operation which includes the distribution of the trephines; and (4) the actual operation itself.

Recent cases with a hole well forward are especially favorable for this therapy, while cases with huge holes, extending sometimes halfway around the globe at the ora, with marked retraction and folding of the retina at the edge of the hole, are wholly unsuitable.

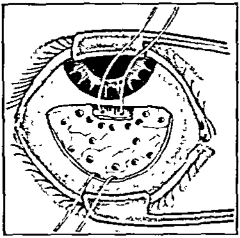

Fig. 495 —The completion of the Lindner-Guist technique.

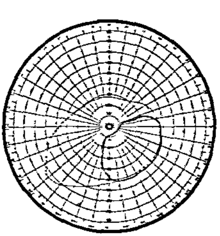

Fig. 496 —Solid line, the form field before operation; dotted line, after operation

The chief difficulty with this operation is the avoidance of perforation of the globe by a trephine before all those which were planned have been cut. Completion of the operation is almost impossible if this should occur. It is not so serious should this occur with one of the last trephine openings planned, for one can usually apply the caustic to those openings already made, though even this may be difficult because of the resulting hypotension. Black suggested using a purse-string suture to close a perforation should it occur early in the operation, or even using three sutures placed into the sclera at the angles of a small triangle, and then by pulling these taut, an island of sclera is outlined having sufficient resistance to permit the use of the trephine blade. Any one who has experienced this above complication will appreciate the value of Arruga's screw plugs for temporarily sealing a perforation.

Trephining with detachment of the choroid and with infiltration of potassium hydroxide is, according to Lindner, especially satisfactory for

[1] Trans. Ophth. Soc. United Kingdom, 52, 456, 1932.

rents which are located at the macula, though it can be used in any other case to minimize the number of trephining openings necessary to cover a separation.

In general, regardless of the type of surgery which is used, it is never wise to attempt to correct a case of massive separation of the retina at one operation. For instance, Figure 496 is the residual field of the right eye of a patient who had had a massive separation nasally and inferiorly. A successful result was obtained in this instance through surgery by three operations, a Walker nasally, trephining below, and a Larsson form of superficial coagulation nasally along the horizontal axis. Visual acuity after the operation was 6/45 and the form field which resulted after the operation appears in a broad dashed line. One hole only was found in this case, above near the equator and slightly to the nasal side. It is the hole *A* in Figure 485.

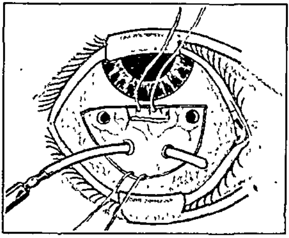

Fig. 497 —Trephining with subchoroidal drainage.

Figure 497 illustrates diagrammatically two trephine openings according to this technique with a cyclodialysis spatula in place, having been passed from one hole to the other separating the subchoroidal space from the sclera. With the exception of rents at the macula, this technique should not be used for retinal tears. It is best to surround them with trephining openings as just described. The use of two holes for subchoroidal injection permits the fluid which has been injected, usually a 6 per cent solution of potassium hydroxide, to flow from one hole to the other, though in the handling of macula holes this is not always possible. Lindner feels that the adhesive choroiditis which results from this caustic should be generally successful. In spite of the difficulties connected with it, it is undoubtedly a very satisfactory method of handling a macula retinal laceration The trephinings necessary are outlined upon the sclera and a subchoroidal detachment obtained. The caustic solution is then injected along the path of this tunnel through a blunt cannula, similar to that used for lacrimal canaliculus irrigation, using from $\frac{1}{50}$ to $\frac{1}{30}$ of a cc. of the solution. In discussing the treatment of macular holes with this injection method, Walker[1] has been *most successful in applying* the Lindner undermining method, using a 3 per cent solution of potassium hydroxide. Lindner's original

[1] Am. Jour Ophth, vol 19, No. 5, May, 1936.

technique[1] abstracted by Walker is essentially as follows: Lindner's original undermining procedure was accomplished by using a sharp discission needle and under binocular magnification, a 2 or 3 mm. linear scleral incision down to the choroid, on the temporal side of the eye, from 20 to 26 mm. behind the limbus, so that a distance of only 10 or 12 mm. of undermining with a calibrated spatula between sclera and choroid would be necessary to reach the suprachoroidal space immediately behind the macula. Under ophthalmoscopic observation, the movements of the undermining spatula or of the special injection needle could be observed as a control of accuracy, while 0.02 cc. of a solution of KOH, varying from 2 to 4 per cent in strength, was injected. A 0.25 cc. syringe was used, fitted with a special, curved, stiff, alloy needle, flattened and closed at the tip like a spatula. There was a single opening in the side of this needle 2 mm. from the tip.

Walker's own special needle has a 2.5 cm. length of rather stiff rubber tubing interposed between the needle tip and the syringe, fitting so that, according to Walker, "when the needle is in position subsclerally toward the macula, the barrel of the syringe may be lowered out of the way of the ophthalmoscope in a line running somewhat horizontally across the upper margin of the cornea. This at once permits the direction of meridian of the macula to be established, both for the undermining spatula and injection needle. Walker observed on the eyeball and on models, that when the sclera was trephined immediately above the center of the inferior oblique attachment, (1) the macula, (2) the trephine center, (3) the upper end of the external rectus stump, and (4) the upper margin of the clear cornea established an accurate meridian along which the needle and tubing may be directed to the macula. The needle and tubing are easily held in good approximation alignment by forceps at the needle end and by the syringe barrel at the other end of the tubing. When close to the macula, the needle tip may be given motions to be identified ophthalmoscopically by moving the syringe barrel or by gentle pressure of the fixation forceps on the needle or the tubing, 5 or 10 mm. from the trephine opening. Instead of a single sawtooth opening in the side of the needle, well behind the tip, which can act like a hook, as in the Lindner model, and scratch the choroid, producing hæmorrhage or premature loss of fluid, Walker's needle has a through-and-through double opening as close as possible to the tip, which allows a more uniform distribution of alkali and is much more readily cleaned. Behind these openings the needle is lightly marked at 9, 10, and 11 mm., and the rubber tubing, also serving as a depth gauge, is usually set at 12 mm. although, if necessary for a long eyeball, it can be set back several mm. more. In such a case (over 10 D. of myopia) *the upper edge of the dilated pupil instead of the upper edge of the cornea* is used for the alignment.

Other authors have used sodium hydroxide in stick form and carbolic acid (phenol) as well. Scleral trephining is perhaps the most difficult of the operations for retinal separation because of difficulty in obtaining the extensive exposure necessary for the trephine openings. It is, therefore, limited in its application.

Surface Therapy.—A thermophore has been recommended by several men and satisfactory results have occurred through the use of the thermo-

[1] Klin. Monatsbl. f. Augenh., 90, 757, 1933.

phore. Langdon's[1] report was probably the first one outlining the use of Shahan's thermophore. According to Langdon's presentation, a sclerotomy was done followed by a treatment with Shahan's thermophore, the application to the sclera being one minute at a temperature of 160° to 165° F.

This type of surgery is not applicable to the larger separations, but in similar cases with small fresh separations it is to be seriously considered It may also be considered for other cases wherein an incomplete recovery has occurred following other forms of surgery with a residual which remains in the instance only slight in amount and easily reached with a thermophore.

It is important that some form of sclerotomy be added to the surface therapy to permit complete drainage of the subretinal fluid. Very probably this drainage should follow the surface therapy, and it must be controlled by direct observations with an ophthalmoscope.

It is rather likely that surface therapy should be used more than it is. Holes present in the retina must be sealed regardless of the type of therapy used. Surface diathermy will not do this. A combination, however, of micro-needles to rim a hole or a disinsertion, the application of a thermophore, to the remaining portion of the detached retina, and lastly, subretinal drainage by some type of sclerotomy, the procedures being done in this sequence, is a sound technique for many of the lesser detachments.

Minimal flat separations early after a recovery from the surgery of a cataract extraction should lend themselves well to it. When Lagrange recommended colmatage, (multiple cautery of the strip of sclera parallel with the corneal limbus after dissecting back the conjunctiva) for retinal separation, he anticipated, according to van Heuven,[2] the virtues of modern retinal separation surgery by the application of heat, though he failed to consider the importance of the retinal hole and the matter of subretinal drainage.

The exposure of the sclera is the same as that which one would carry out for any type of scleral surgery. Langdon states that the reaction is not marked, but that there may be some difficulty in handling the thermophore tip and the sclera in that region of the eyeball involved. The hermic surface therapy of Coppez is similar in principle to that obtained with the thermophore.

Surface or Discleral Coagulation.—Surface or discleral coagulation is a procedure first advocated by Larsson. His first paper, read before the Heidelburg Congress of Ophthalmology in 1934, detailed the experimental work started in 1923. The work of Weve parallels that of Larsson with the exception of individual characteristics. Larsson's ball-shaped electrode is from 2 to 3 mm. in diameter, while Weve's is from 3 to 4 mm. in diameter. Von Szily and Machemer use a bipolar electrode for surface therapy with the two poles terminating in points 1 mm. apart. Larsson used a current of 40 milliamperes with his technique, and a smaller ball, while Weve must use from 100 to 150 milliamperes. Marshall, at the Royal London Ophthalmic Hospital, uses a small point-shaped, bent electrode of 0.66 mm. with a current of no higher than 20 milliamperes. In general, the larger the electrode the greater is the amount of current necessary. Von Szily and Machemer's bipolar electrode is used with a current of 30 milliamperes for about ten seconds application at each point. There is a

[1] Am Jour. Ophth, vol. 18 No 6, June, 1935
[2] Klin Monatsbl f Augenh., 76, 340, 1926.

from 20 to 80° C. it is necessary to work slowly for twenty or thirty seconds. With the same time of application and size of electrode, the same effect is always obtained at the same temperature, whatever the conditions may be. Consequently it is possible to study the effects of treatment on the basis of precise anatomic findings in place of clinical approximation. These conditions being realized, the coagulation gives perfect adhesions between the choroid and retina without any damage to the vitreous or to the sclera. The optimum temperature is 80° C.; my experiments have shown that 70° C. is not sufficient, and 90° C. produces too severe reactions. With a 2.5 mm. pyrometric electrode at 80° C. for from twenty to thirty seconds, the results have always been uniform.

In utilizing his technique, the evacuating trans-scleral punctures are done through a cauterized area so that any risk of hæmorrhage is avoided thereby. These drainage punctures may be made with any one of the usual electrodes already mentioned and according to the localization methods of Weve.

Treatment by Scleral Penetration.—Thermo-cautery.—The surgery of ignipuncture is Gonin's creation. For this reason it is proper to speak of ignipuncture as Gonin's thermo-cautery operation. As early as 1904,[1] Gonin stated that he had satisfied himself as to the correctness of Leber's theory which insisted that retinal separation was the result of subretinal fluid which has passed from the liquid part of the vitreous into the subretinal space through a tear in the retina. He based his explanation upon the frequent presence of a crescentic or horseshoe-shaped tear with the flap, always projected into the vitreous body, and *with its apex toward the papilla and its base to the periphery, these peculiarities showing that the tear was due to traction on the retinal tissue from behind forwards and inwards.*

The various steps in the Gonin operation have been repeatedly described. Arruga's recent description[2] restates it in abstract. Schoenberg's description[3] is quoted verbatim. It presupposes an accurate localization of the retinal tear which is being treated.

(1) It is not advisable to use instillation of cocaine as a local anesthesia. This drug injures the corneal epithelium for the time being and makes ophthalmoscopy difficult immediately after the ignipuncture. (2) A strabismus hook introduced underneath the tendon of the proper muscle is of considerable aid in pulling the eye in the direction desired so as to make an area situated far behind the equator accessible to the cautery tip. (3) When possible, the incision in the conjunctiva should be at least 3 or 4 mm. behind the area of ignipuncture After the incision, the conjunctiva is undermined with a few snips of the scissors, and a lid retractor (Desmarre) is introduced underneath the conjunctiva and Tenon's capsule. In this way a larger area of sclera is exposed and the margin of the lid is protected from accidental contact with the cautery tip. If the area to be punctured happens to be underneath one of the recti muscles, it is permissible to perform a preliminary temporary tenotomy. (4) The lips of the scleral incision often come so closely in apposition that one fails to find the opening. It is perhaps better to make a mark on the sclera with India ink or with the cautery before the Graefe knife is introduced. (5) The cherry-red hot tip of the cautery should be introduced about 3 or 4 mm. into the vitreous, directed toward the center of the eyeball and kept in from two to four seconds. If one wishes to cauterize a larger area of the retina and choroid, one can reintroduce the cautery tip bent in the shape of an L. (6) It is both useful and instructive to examine the fundus immediately before and after the incision of the sclera and after ignipuncture. Since the operation is performed when the patient is in the recumbent position, the final decision as to the exact location of the tear should be made while he is on the operating table. Occasionally the loca-

[1] Trans. Am. Ophth. Soc. United Kingdom, 50, 531, 1930.
[2] Arruga: Detachment of the Retina, translated by Castreviejo, Barcelona, 1936.
[3] [illegible], 6, No. 5, 079, 1931.

and again until the entire area of retinal separation has been covered. As the surface coagulation progresses, one is aware of the fact that the eyeball is becoming appreciably softer. Regions of the sclera in which retinal tears lie must be completely covered with surface coagulation even to the extent of having these brown parchment-like regions overlapping one upon the other. As soon as the surface therapy is completed, the subretinal fluid is to be drained by one of several methods. Two or three scleral trephining holes depending upon the size of the separation may be made, and the choroid which presents in these perforated with scissors or a keratome. Trans-scleral ignipuncture may be used for the drainage if desired. A sclerotomy can be done with the tip of a cataract knife making these incisions crucial shaped, or best of all, drainage can be obtained with the special electrocoagulation electrodes of Walker, of Šafář, or with Weve's or Meesmann's needles. Walker's and Weve's needles are protected with a glass collar and the puncture can be made with as much of the electrode exposed as is desirable and necessary. Weve feels that all types of subretinal drainage for the Larsson technique are unsatisfactory because of choroidal damage, except that which is obtained through multiple punctures with these adjustable electrodes.

Surface coagulation can be very nicely combined with the micropuncture operation (which will be subsequently described). This is applicable, especially in the treatment of large disinsertions and with definitely localized retinal lacerations. The surface coagulation is first carried out, and subsequently, the micro-cautery punctures, around the disinsertions and the tears using needle electrodes from 0.2 to 0.4 mm. in thickness and varying in length from 0.75 to 1 mm. Longer needles, however, may be used, as has been previously described, of varying thicknesses and varying lengths to locate more accurately the tear. Marshall's description of Weve's technique, as he saw it carried out in Utrecht, is as follows:[1]

> In spite of the great care which Weve takes over the preliminary examination and marking out of the tear with his special marking technique, he also uses long needles of various thicknesses and lengths to locate the tear. These long needles are made in three thicknesses and have a small, movable cuff which allows the needle to be marked off for certain lengths. In making a preliminary mark, a needle 1.5 mm. is usually used, but sometimes it is necessary to use one 3 mm long. When the approximate mark is made on the sclerotic, a violet aniline pencil is sometimes used, but generally India ink is the marking agent—the long needle is plunged into the globe, and on examination with the ophthalmoscope a white spot one-third of the diameter of the disk is seen on the retina, provided that the needle has been plunged in far enough This mark shows how accurately the surface-marking has been carried out. If no mark has been made, he uses a perforating needle with a longer point. These long, straight needles are also very useful for letting out subretinal fluid.

In addition to this operative localization, Weve and Walker also use the ophthalmoscope very frequently for localization during an operation. The examination may be done by the indirect ophthalmoscopic method. If Weve fails to find a whitening of the choroid or the retina in the region of the tear after surface coagulation, then he proceeds with needle punctures as follows: a 1.5 mm. length point is applied to the sclera, and with current the sclera is perforated with this. He waits about two seconds, shuts off the current, and then again closes the current withdrawing the needle point

[1] Marshall: Detachment of the Retina, Oxford Medical Publications, London, 1936.

under current, taking about two seconds longer for the withdrawal of the needle. He again re-examines the retina in the neighborhood of the tear, and if he fails to find the white area in the retina previously mentioned, he uses a 3 mm. needle. When withdrawing the longer needle, Marshall states:

He (Weve) likes to do it slowly so that he endeavors to attract the retina and cause it to follow the needle point. This generally shows a definite white spot in the retina and shows exactly how the punctures have been placed as regards the closing of the tear. Here again, if he is not satisfied, he uses a special speculum. This speculum is a concave, oblong-shaped spoon bent at right angles to the handle, which is insulated against the electrical current. The spoon is held by an assistant who places it between the sclera and the subconjunctival tissue in the region of the tear. The professor shines the light from his mirror on the tear and the assistant manipulates the speculum with its nickel-plated surface until the light is seen shining through the sclerotic. The spot where the light is seen is compared with the previous spot marked on the sclerotic. If this spot does not compare with the light beam, a new spot is made and then fresh punctures are carried out again. The fundus is examined until the operator is sure that the procedures are properly placed. If the speculum is not suited for a tear placed very posteriorly, a special pencil-shaped periscope can be used. This is moved about until the light from the mirror is reflected along the tube. If a flap is present, Weve perseveres until the flap is stuck down by the punctures. He does this to stop the flap from dragging on the vitreous. When he has finished the operation to his satisfaction, a white, flat scar is seen in the region of the tear. This scar, in many ways, is like a scar produced by the thermopuncture operation of Gonin. It obliterates the tear and sticks the retina down, but it does not have the same serious results of the thermopuncture operation scar, which often causes folds in the retina and subsequent secondary tears.

In fact, in his latest technique, Weve apparently aims to get a bed of choroidal coagulation against which the retina sticks because the micropunctures actually reach the retina itself. Since this method has been used, the percentage of cures in the Utrecht clinic has risen to the high figure of 90 per cent. Weve feels that success of his operation is due to the careful and repeated examination of the tear region, during the operation, and to the certainty of having closed the tear or the area of a disinsertion. At his operations he also carefully searches the fundus to see if he has missed any tears at previous examinations; also the flattening of the retina at the operation may expose tears which were hidden before. The muscle sutures are tied and the conjunctiva closed as before to complete the operation.

Pyrometric Electrode.—In discussing surface or, as Coppez calls it, "scleral diathermo-coagulation," Coppez[1] feels that the use of a pyrometric electrode[2] is an ideal way of provoking choroidal irritation and subsequent postoperative correcting adhesions with least damage to the retina and with uniformly favorable results. His electrode is a ball 2.5 mm. in diameter, used in the same way as was described for the Larsson technique. Instead of reading the milliamperes, however, one reads the registration on a pyrometer. In the review of his work which Coppez published in *Archives of Ophthalmology*, January 1935, he stated as follows:

The principal point of my method is that it is not a rapid coagulation, but a slow heating of the sclera, which is the only way to get uniform coagulation. Pyrometers always have a certain degree of inertia, and to know the exact temperature

[1] Arch. Ophth., vol 13, No. 1, January, 1935.
[2] Arch. internat. de med. exper., 9, 177, 1934; Bull. et mém. Soc. franç. d'opht., 45, 251, 1932; Ibid., 46, 312, 1933

from 20 to 80° C. it is necessary to work slowly for twenty or thirty seconds. With the same time of application and size of electrode, the same effect is always obtained at the same temperature, whatever the conditions may be. Consequently it is possible to study the effects of treatment on the basis of precise anatomic findings in place of clinical approximation. These conditions being realized, the coagulation gives perfect adhesions between the choroid and retina without any damage to the vitreous or to the sclera. The optimum temperature is 80° C.; my experiments have shown that 70° C. is not sufficient, and 90° C. produces too severe reactions With a 2.5 mm. pyrometric electrode at 80° C. for from twenty to thirty seconds, the results have always been uniform.

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(and perhaps unnecessarily so) thereby. There are definite factors of danger in the diathermy treatment of retinal separation. These are connected with the too extensive application of the micropuncture needles over too great an area with the use of too many needles, and with the lower degrees of current applied for an unnecessary length of time. Currents of a high intensity are also dangerous, but in this instance the danger applies not only to the sclera, but is also connected with damage to the vitreous, damage to the retina, and most important of all, results in unsatisfactory postoperative results and without recovery of the retinal separation.

The various instruments which are available have been described in the literature in great detail. They include the various needles of Walker, some curved, others straight, double-pointed and triple-pointed, to be applied either with forceps or with a stylus; the electrodes of Šafář, these being single-pointed or with multiple points, some attached in groups to a handle for convenient application by a stylus, the others to be applied singly by means of holding forceps. Walker's needles are usually threaded with black silk for easy identification and to prevent their loss or the inadvertent retention of one or more needles at the close of the operation Thorpe[1] has used pins which he makes himself. He feels they are even more satisfactory than the Walker needles. They are made of gold-plated brass wire 26 gauge size; a piece of this wire is taken and looped about a small stylus similar to one used for dilating the canaliculus. The tiny portion below the loop is sharpened at its point, and the pins, when used, are introduced without a silk thread attached. He uses two sizes, usually, the smaller of the two having available pin surface of 1.2 mm. in length (used over flat areas of detachment), the larger of the two, 1.8 mm. in length (used over more gibbous areas of detachment). Thorpe feels that the electrocoagulation effect obtained from these needles is greater and more satisfactory than that obtained from the platinum needles. With the exception of some of Šafář's single electrodes, the other electrodes which are used are of such a size that it would be quite difficult to permit their inadvertent retention after completion of an operation. Meesmann's electrodes are a series of shouldered needles of various sizes and shapes, applied through a stylus consisting of an insulated handle with a terminal tube of quartz through which are passed the interchangeable points of platino-iridium. The electrodes of Coppez and his stylus are somewhat different in shape and size, some being ball-pointed, others sharp-pointed with terminal needles at their apices and others flat. The electrodes of Weve consist of an insulated portion with the terminal end being bent and with a terminal metallic needle of various lengths protruding from the tip of this insulated material. These are applied through a stylus into which his electrodes fit. The electrode of Lacarrère is an insulated stylus with its active electrode protruding from a thin glass tube at its apex. This tube is slightly curved and beveled for close adaptation to the sclera. The platinum wire electrode may be projected from the glass tip any desired length depending upon the degree of penetration which is necessary. Walker's electrode is especially for the use of galvanism and is arranged somewhat similarly, so that any amount of penetration which is needed may be obtained. The electrodes for negative galvanism, *i. e.*, electrolysis with the cathode as the active pole, is a matter of bipolar application. Vogt

[1] Personal communication.

tion of the tear shifts during the change from the sitting to the recumbent position. After the escape of the subretinal fluid there is again more or less displacement of the retina and tear, and this should be ascertained by an ophthalmoscopic examination. (7) Finally after the ignipuncture the ophthalmoscope reveals the extent of the cauterization, also whether the retina has been anchored on the choroid. One can see a dark round area (the hole in the sclera) surrounded by an almost black, more or less complete, narrow ring, outside of which there is a grayish-white zone of partly edematous and partly necrosed retina. The extent of this white area depends on the size of the cautery tip and the length of time that it has been kept in the opening. In other words, the result depends on the amount of heat per second applied to the tissues of the eyeball. At times no vitreous flows out after the scleral puncture. This is usually due to the thickness of the albuminous subretinal fluid. (8) As soon as the sclera has been exposed it should be carefully inspected. Some cases show a slight bulging, and others a thinning of the sclera, with the choroid shining through; in other cases, one finds a marked engorgement of the episcleral blood-vessels. Whatever the meaning of these observations may be, it is wise to make a record of them (9) Though a minor detail, it is nevertheless important to instill salt solution frequently and regularly into the conjunctival sac. The cornea must be kept moist to make ophthalmoscopy possible. It is of paramount importance to record at the conclusion of the operation the principal steps, the unusual observations and the complications encountered. (10) The binocular bandage is to be removed every two days, the lids cleansed and a drop of a 1 per cent solution of atropine instilled (never salve, because it interferes with ophthalmoscopy).

It is proper to emphasize again the postoperative dressing necessary and satisfactory for this type of surgery. The eyeball should be protected from the pressure of the overlying bandage by building a ring or horseshoe of absorbent cotton about the eyeball upon the bony configuration of the rim of the orbit, so that the eyeball itself is free of pressure, and the position of the patient in the bed should be arranged so that gravity will assist in the drainage.

Arruga's statement relative to the results from thermo-cautery, or galvano-cautery as it is frequently called, is sufficient to assure us that this original operation is as yet not to be relegated to the obsolete.

In spite of the fact that most oculists nowadays do not use the thick thermo-cautery or galvano-cautery, as those were at first, it has to be admitted that in cases of very bullous detachments with the rent in the most protruding portion, the thick cautery, provoking a vitreous prolapse through the sclero-choroidal hole is a very efficacious means of cure. It necessitates, however, the exact localization of the tear. For best results with the modern methods, retinal detachment should not be so bullous; and an attempt should be made to reduce this protrusion before the operation through the use of rest or punctures, or at the close of the operation through the injection of air into the vitreous [1]

Diathermy.—Sealing retinal tears and the adhesive choroiditis obtained through penetrating electrocoagulation is called diathermy. The thermic or cutting action of the current, as exerted upon the sclera by the small active positive electrode, permits subretinal drainage and the re-application of the separated retina. The hole becomes sealed by reason of the circumferential chorio-retinitis which develops from the coagulation of the tissue at the point of penetration. Diathermy current with the plus or active electrode has a rapid penetration action with but little coagulation if the current is high in intensity and if the action of the penetration occurs rapidly. When the current is low in amperage, coagulation is greatest in amount, perforation occurs very slowly, and the degree of adhesive postoperative chorio-retinitis which occurs is probably also greatest in amount

[1] Arruga: Detachment of the Retina, Barcelona, 1935.

(and perhaps unnecessarily so) thereby. There are definite factors of danger in the diathermy treatment of retinal separation. These are connected with the too extensive application of the micropuncture needles over too great an area with the use of too many needles, and with the lower degrees of current applied for an unnecessary length of time. Currents of a high intensity are also dangerous, but in this instance the danger applies not only to the sclera, but is also connected with damage to the vitreous, damage to the retina, and most important of all, results in unsatisfactory postoperative results and without recovery of the retinal separation.

The various instruments which are available have been described in the literature in great detail. They include the various needles of Walker, some curved, others straight, double-pointed and triple-pointed, to be applied either with forceps or with a stylus, the electrodes of Šafář, these being single-pointed or with multiple points, some attached in groups to a handle for convenient application by a stylus, the others to be applied singly by means of holding forceps. Walker's needles are usually threaded with black silk for easy identification and to prevent their loss or the inadvertent retention of one or more needles at the close of the operation Thorpe[1] has used pins which he makes himself. He feels they are even more satisfactory than the Walker needles. They are made of gold-plated brass wire 26 gauge size; a piece of this wire is taken and looped about a small stylus similar to one used for dilating the canaliculus. The tiny portion below the loop is sharpened at its point, and the pins, when used, are introduced without a silk thread attached. He uses two sizes, usually, the smaller of the two having available pin surface of 1.2 mm. in length (used over flat areas of detachment), the larger of the two, 1.8 mm in length (used over more gibbous areas of detachment). Thorpe feels that the electrocoagulation effect obtained from these needles is greater and more satisfactory than that obtained from the platinum needles. With the exception of some of Šafář's single electrodes, the other electrodes which are used are of such a size that it would be quite difficult to permit their inadvertent retention after completion of an operation. Meesmann's electrodes are a series of shouldered needles of various sizes and shapes, applied through a stylus consisting of an insulated handle with a terminal tube of quartz through which are passed the interchangeable points of platino-iridium. The electrodes of Coppez and his stylus are somewhat different in shape and size, some being ball-pointed, others sharp-pointed with terminal needles at their apices and others flat. The electrodes of Weve consist of an insulated portion with the terminal end being bent and with a terminal metallic needle of various lengths protruding from the tip of this insulated material. These are applied through a stylus into which his electrodes fit. The electrode of Lacarrère is an insulated stylus with its active electrode protruding from a thin glass tube at its apex. This tube is slightly curved and beveled for close adaptation to the sclera. The platinum wire electrode may be projected from the glass tip any desired length depending upon the degree of penetration which is necessary. Walker's electrode is especially for the use of galvanism and is arranged somewhat similarly, so that any amount of penetration which is needed may be obtained. The electrodes for negative galvanism, *i. e.*, electrolysis with the cathode as the active pole, is a matter of bipolar application. Vogt

[1] Personal communication.

uses a very fine needle which can be introduced any desired length, the anode in this instance being a simple ball terminal. Von Szily and Machemer use bipolar electrolysis with the two poles in the same stylus, the anode being blunt and the cathode long and pointed, so that the latter can pierce the sclera the desired length for the necessary time and with the best intensity of current needed.

In general, the technique of the individual operator has but two important points as the basic premise. First, subretinal drainage, and second, the sealing of the retinal tear. Any method which achieves this satisfactorily is sufficient grounds for its use, all other things being equal, *i. e.*, availability, adaptability, and the minimum possibility of danger. The personal likes of the operator therefore are a strong factor. There is no doubt in the writer's mind that the electrodes of Šafář and the micropin of Walker are the most readily used for the grosser and more serious cases of retinal separation because of their adaptability, and the fact that they retain the tension of the eyeball until the end of the operation. On the other hand the electrodes of Meesmann and of Weve, and especially the electrode of Lacarrère, are quite adaptable to treatment under and about the ocular muscles, especially the oblique at their scleral insertion and for treating the sclera at the posterior pole of the eyeball. The rapidity with which one can work with these electrodes as compared to the micropin may offset some of the disadvantages of losing the subretinal fluid. Walker has arranged bident, hook electrodes, however, for posterior therapy which, if combined with the use of his micropins, should make all regions of the scleral shell equally available for therapy.

In the use of micropins or the adjustable electrodes, the beginning of the operation is no different from any other form of retinal separation therapy. The conjunctival incision should be extensive, the sclera must be carefully and completely bared, the muscles resected, as is necessary for exposure, and the traction sutures passed through the stumps of the muscles after the tenotomy has been done. The next step is to mark upon the sclera the position of the tear. The operator is armed with his preliminary examinations and the projection of these findings upon the charts already mentioned. The stylus of Walker, without a micropin, makes a very satisfactory marker when it is applied to the sclera with from 30 to 40 milliamperes of current. It leaves a dark brown to gray mark which will remain throughout the duration of the operation. With this stylus the meridian can be marked in which the tear lies, the position of the ora serrata, and the estimated position of the tear. There are several very satisfactory scleral rules available. Walker's double-ended rule which is subdivided into millimeters is quite convenient. Amsler has a similar set of markers. The Macky marker has a movable cuff for estimating distances. A pair of ordinary dividers with sharp points combined with a metal or glass rule subdivided in millimeters and in half-millimeters is, in general, quite satisfactory for everything except for determining measurements rather far posterior. The Macky scleral rule is most convenient for the deep posterior measurements. Before further surgery is carried out, localization should be confirmed by trans-pupillary illumination, using an Arruga spoon as a speculum and reflecting mirror, or by using preliminary micropins, longer electrodes, or cathode current. Regardless of which of these is used, they should be controlled ophthalmoscopically. (A warning is repeated here

against the use of cocain for surface anesthesia, in that it interferes with ophthalmoscopic examination. It is equally important to prevent drying of the cornea from simple exposure during these preoperative steps. This can be prevented by irrigating it frequently with a few drops of warm physiological saline solution.) In working with the micropins, it is quite necessary to keep the operative field dry and to prevent short circuiting of the current by contacting the conducting tip of the stylus with metal parts or with other needles. The retraction of tissues is readily obtained by narrow ivory rods, a tortoise shell lens spoon, or by means of the Arruga speculum. While this is metal, its concavity is sufficiently deep to give adequate working space within this concavity without danger of short-circuiting the therapeutic current. As soon as satisfactory localization has been achieved, the micropins are first placed about the tear. The sclera must be absolutely bare and dry. In addition to these micropins, one may use, for sealing the tear, Walker's beading needle which is passed through the sclera obliquely, or any one of the other electrodes outlined previously. Walker uses micropins with white threads for his markers and localizing pins, and also at times for special use, as when used to rim a tear The micropin is taken from the gauze upon which it is threaded, or from his finger magazine, looped over the stylus, and applied to the sclera As it touches the sclera, the current is closed and the pin introduced with from 30 to 40 milliamperes of current. As soon as it is introduced in its position, the current is continued for a moment longer, and then the pin is released by the operator from the stylus, at the same time releasing the thread which has been held taut between the thumb and index finger. The operator, while *introducing micropins, should be careful not to contact those* with others already in place. Those already in position will be overdosed, the current will be divided, and the available current needed for the introduction of the pin being used cut down. The various needles of Šafář's and Weve's brushes and nails are insulated one from the other so that this matter is automatically corrected. The thread is moved to the side away from the field of operation. Under ordinary circumstances, in an unobstructed field, 8 to 12 pins can be placed in each minute of elapsed time After the pins have been placed about the hole, the limits of the separation are then outlined with a line of pins, these being inserted, 2 mm. apart. Subsequent pins are used, as is necessary, within the field of the separation. Short pins are used to outline the separation; the longer ones about the tear, and, if necessary, quill pins, and bi- and trident pins are inserted for drainage. In introducing the pins they should be held perpendicularly and not introduced obliquely. Forceps have been made by Walker for operators who do not like the individually threaded micropins. One arm of these ends as the stylus, the other arm fitting outside the loop of the micropin. With these forceps, even the threads may be discarded by using platinum-blacked pins to prevent their loss or inadvertent retention. Walker avoids large drainage openings immediately over the tear because he feels that vitreous loss from herniation through the tear should be combated. Walker's quill is made of 25 per cent iridium-platinum tubing, $\frac{35}{1000}$ of an inch or about $\frac{7}{8}$ mm. in diameter which corresponds to 20 gauge needle. The quill has a length of about 2 mm. and the edge is sharpened both inside and out. Enough of the tubing is left to solder it with platinum to the microtip coil so that it fits the regular stylus and handle. The tubular portion of the

quill is filled with platinum solder so that when it is used with the diathermy current, it cuts a semicircular opening, and then plugs it as the solid portion of the tubing reaches the opening, and pushes the retracting scleral tongue back. There may be a minute bit of leakage while this quill is in transit through the sclera, but often 5 or 6 can be used, if it be deemed necessary, before the eye softens. Walker says:[1]

> Since the current is more intense at sharp points or edges, the cutting effect of this device with a given current is much greater than a conical tip would require to make the same opening, and the damage to the sclera is correspondingly diminished because it requires very little current, sometimes not much more than the microtip

This "trephine quill," as he speaks of it, compared with a trephine, inhibits the tendency to hæmorrhage because of the coagulation which occurs. It gives a desirable opening and has the same advantages, as regards cleaning, as have his other platinum pins, in that it can be flamed in a bunsen burner.

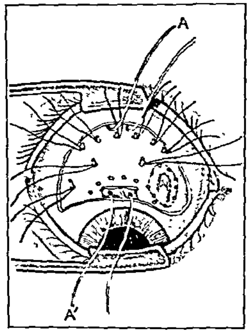


Fig. 498.—The field of operation after the introduction of Walker's micropins. Note how the scleral representation of the hole has been rimmed. *A*, suture on detached muscle; *A'*, traction suture on stump.

The limits of the separation when extremely posterior can be treated further with his bident hook. This is introduced into the stylus, applied firmly to the sclera, and the current then closed. The points penetrate the sclera giving superficial coagulation and drainage as well. Figure 498 is a sketch illustrating the field of operation at the completion of the operation. A superior temporal tear near the ora has been rimmed about with micropins, the limits of the separation rimmed with pins, and within the confines of the separation the larger quills can be used for drainage. If at any time during the operation a needle is pulled from its insertion, it should be immediately replaced into the same hole. Ordinarily, the micropins hold with a fair amount of resistance. It has been estimated that the pull necessary for removing them averages somewhat more than 6 ounces. As long as the micropins remain in position, there is little if any loss of subretinal fluid, and the eye will not become unworkably soft. As soon as all the areas have been satisfactorily covered, it may be advisable to again make an ophthalmoscopic examination. If the cornea has been properly protected during the operation, there should be no difficulty in doing this. One should look at the position of the tear and determine the presence of satisfactory retinal coagulation about it. The limits of the tear should be seen as having been outlined, and one must be certain as to the presence of retinal

[1] Am. Jour. Ophth., vol. 17, Ser. 3, January, 1934.

hæmorrhages. In regard to this, it is important to localize the vortex veins on the scleral surface and to pay special attention so that they are not traumatized. In working deeply posterior around the region of the macula, the scleral insertions of the oblique muscles are very satisfactory guides. These overlie the macula region above, below, and upon its temporal margin. They should not be injured during the coagulation to prevent adhesions, but they can be lifted and micropins inserted beneath them

Before the needles are withdrawn, one should be certain to identify the retaining sutures upon the muscles, as A in Figure 408, as well as the traction sutures upon the muscle stump as with A′. The micropins are then withdrawn one after the other, the threads upon them being gathered together into one bundle. It is wise to withdraw these pins first about the periphery of the separation, then those about the tear, and last the remaining intermediate pins. The subconjunctival spaces are sponged dry of the subretinal fluid, irrigated with a 1 to 10,000 metaphen aqueous solution, the muscle stump traction sutures removed and the muscles then accurately sutured to the stump by the double-armed ends of the black-braided suture which had been whip-stitched into the muscle before the detachment. The ends of these are brought out through the juxtalimbal lip of the conjunctiva and tied. The conjunctiva and Tenon's capsule are then closed with interrupted sutures or with a continuous suture, atropine instilled, and the eye dressed.

In recapitulation, especially in regard to the treatment of the flat type of separated retina, Walker[1] calls attention to several rather important points:

(1) In order not to injure the retina when diathermy is being used, curved, 1½ mm single micropins are the best type for barraging over flat retinal detachments These pins stick much more firmly in the sclera, can be used without threads, and lie so flat to the sclera as to permit of free rotation of the eyeball (2) The detachable four-prong, short-stop pin, in diamond-pattern arrangement and penetrating only to the choroid, is the most useful multiple pin when sizable areas have to be rapidly treated with minimal leakage. (3) Treatment of all pins while still in the sclera with one second of a 1 mm negative galvanic current offers a further excellent aid to closure of the unexpected retinal holes that are frequently seen on careful inspection after micro puncture, especially in regions of shallow detachment, even when every precaution has been taken to forestall them (4) The injection of $\frac{1}{20}$ cc of 3¼ per cent alkali with a special syringe and needle after a subscleral undermining to the back of the macular choroid has been made, has given excellent treatment of macular hole. Alkali may also be produced galvanically in the same undermined region under easier ophthalmoscopic control and with very similar results (5) Recent observations lead to the conclusion that macular weak spots and small holes, which may easily be overlooked without a very sharply focused strong light in the ophthalmoscope, have been present together with instances of larger holes in over 10 per cent of the cases observed.

Šafář's Therapy.—The application of the Šafář electrodes[2] differs not at all from that used for the Walker micropins. These are 1-, 2-, and 3-pointed nails, the points insulated one from the other, which are used for electrocoagulation. They are applied by means of a special holding forceps. The handle holds the nail, and with pressure applied to the sclera it is touched by a small ball attached to the positive pole of the ophthalmotherm. As the current is thus closed by contact to the non-insulated part of the

[1] Am Jour. Ophth., vol 5, No. 6, May, 1936.
[2] Arch. Ophth., vol. 11, No. 6, June, 1934.

instrument, the nail is pushed well home. The forceps is then removed, and the nail left *in situ*. The 2-pointed nails of Šafář are very satisfactory and can be used in practically the same way as Walker's micropins. Because of their slightly greater size, however, they are perhaps not as adaptable. The 3-pointed nails are to be used for intermediate electrocoagulation and for subsequent drainage. Šafář's brushes, as well as those of Weve, are circular or oval plates to which many needles, from 5 to 7 in number, are attached to a handle. Both Šafář and Weve believe in using these brushes in the large bullous separations, and possibly they can be used for treatment at a greater depth within the orbit. These brushes may act practically as a flat electrode and only succeed in severe superficial coagulation of the sclera when used at a great depth. From 150 to 300 milliamperes are required for their use, and the brush may hang so tenaciously into the sclera that one has difficulty in extricating it. If further current is used at this time, overdosage is likely, and further, overdosage has a tendency to reclose the electrocoagulation holes primarily made through the sclera. In regard to the use of the brushes Walker states, "I felt the safest, using single points that can be made to work even at the macular depth by using a little longer curved rubber covered center pin," on the stylus. As Šafář's electrodes are being introduced, the forceps are touched with a ball electrode from the positive pole of the diatherm.

The longer needles of Weve and of Meesmann are used just as are the Walker needles, or the Šafář nails. In some instances, these are retained in the sclera until the end of the operation, and in other instances, depending upon circumstances and conditions present, the trans-scleral electrocoagulation is carried out by the electrodes being introduced and immediately withdrawn. The introduction of these is essentially the same as has been outlined for the micropins.

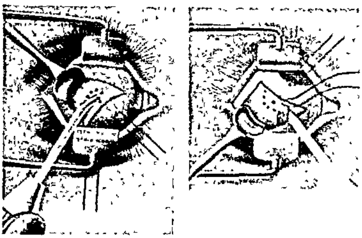
The technique for the fixed and adjustable electrodes of Weve, of Meesmann, of Coppez, and of Lacarrère, is that of a firm application of the electrode needle to the sclera at the desired depth of penetration, closure of the current, withdrawal of the electrode tip, and its reapplication as is indicated.

In Figure 499 are illustrations from Arruga,[1] showing his technique for the use of the Lacarrère electrode. The procedure is as follows:

> A. Two points stained with an alcoholic solution of gentian violet mark the meridian in which the tear in the retina is located. One suture thread is used to draw the globe downward and inward; the other passes through the inferior rectus and out through the lower lid. B. After the incision in the conjunctiva is made, the retractor shown in the illustration retracts Tenon's capsule and the orbital tissues, permitting the posterior part of the globe to be reached. C. With a compass, the distance from the limbus is measured, the distance from the ora serrata to the retinal tear, which was computed ophthalmoscopically, being used in the calculation. D. With a diathermy needle, or with the handle of Lacarrère, the sclera around the tear is perforated. E. In case the tear is a disinsertion at the ora serrata, in the inferior external part (for which reason the silk suture thread in the inferior recess was not passed through the lid), the handle of Lacarrère permits working under the muscle. F. On termination of the operation, the conjunctiva is closed with a silk suture thread untied, which is very easily removed in eight days by simply pulling on one of the free ends.

[1] Arruga, H.: Present Status of Treatment of Detachment of the Retina, translated from the Spanish by S. L. Rhode, Arch. Ophth., vol. 13, No. 4, April, 1935.

This type of surgery results in the more rapid lowering of the ocular tension because of the constant loss of the subretinal fluid; hence, when the surgery has been started, it should be completed as rapidly as is possible. In utilizing these electrodes, the tear should be treated first, and immediately thereafter the operator must carry on rapidly with the treatment of the most posterior portions of the sclera first working forward toward the ora serrata, after those parts have been properly covered. If the eyeball is becoming too soft, further electrocoagulation cannot be continued. Hypotension, short of this degree, can be combated to a certain extent by supporting the sclera with the Elschnig type of toothed fixation forceps, the sclera being lifted and held by these forceps close to the place where the electrode is being introduced. The Lacarrère electrode, by reason of its shape, can be used about and beneath the muscles without resorting to temporary tenotomies; also even if the operative field contains fluid, cauterization can be performed with this instrument as long as the glass tube is held firmly against the surface of the sclera.



A B

FIG. 499.—Retinal separation. A and B, utilization of Lacarrère electrode (Arruga.)

Preparation of Instruments.—*At the end of an operation, the* Walker micropins are all threaded on a platinum wire, the loops of silk through their coils cut, and by passing the wire with the threaded micropins upon it through a bunsen burner, they can be thoroughly cleaned. They are then to be rethreaded and sterilized in an autoclave. In every instance before electrodes or pins are used, the operator must be certain that they have been cleansed of coagulum from previous operations, because the presence of this will interfere appreciably in their satisfactory introduction.

The nails of Šafář and the brushes of Šafář and Weve must be cleaned and sterilized by dry heat. Weve's needles and the electrodes of Meesmann can be sterilized by boiling. The electrode holder of Meesmann and the stylus of Walker and of Šafář can be sterilized in alcohol, and previous to their use, taken apart and thoroughly dried with an ether saturated sponge. Šafář's and Walker's holding forceps can be sterilized by boiling. Lacarrère's electrode may be placed in a flat glass container and sterilized in an atmosphere of formaldehyde vapor. Each instrument has individual

characteristics, however, and attention must be paid to these characteristics to assure asepsis at the surgery, and to obtain best working circumstances for the apparatus.

Gradle's abstract[1] as he carries out his surgery, and as to the essentials of the surgery is so succinct that it is included herewith verbatim.

In using the modified Weve type of operation, having the sclera over the probable location of the hole—surrounding that area by a ring of partly penetrating scleral punctate cauterizations with a Gradle needle—superficial electrocoagulation of the surrounded scleral area with a Weve flat electrode—final and permanent drainage by means of a 0.5 mm. dialet introduced to the sclera with 75 milliamperes of diathermy current—continuous observation of the fundus by indirect ophthalmoscopy must accompany each step. These necessitate a clear cornea throughout the entire course of the procedure.

Cathode Electrolysis.—Cathode electrolysis, *i. e.*, therapy with a galvanic current using the cathode as the penetrating instrument is a form of therapy instituted by Vogt,[2] and first published in abstract in 1934.[3]

Verhoeff and Schoeler both made use of the electrolysis needle in the treatment of retinal separation prior to this, but apparently no great attention was paid at that time to handling the retinal tear.

The treatment depends upon the fact that, as soon as an electrical field is established in a solution, by connecting the electrodes to the positive and negative terminals of a battery, hydrogen ions always migrate toward the negative electrode, *i. e.*, the cathode, and there give up their charge and unite to form molecules of hydrogen gas. The negative ions on the other hand migrate to the positive electrode, *i. e.*, the anode, in that oxygen gas is set free at the anode.

In performing electrolysis it is important to prevent an obscuring number of bubbles, as Walker states, before the tear is satisfactorily localized, otherwise it will be difficult to strike the tear area exactly. Softening of the eye must be combated in order to maintain relations, and, therefore, very fine needles are especially valuable. Because of this importance of maintaining satisfactory relations, preliminary localization with perimetric calculations and transillumination with accurate charting of the findings is just as important in this technique as in any other type of retinal separation surgery.

Walker spoke of neutralizing this alkalinization within the vitreous following negative galvanism by reversing the position of the electrodes. Actually, if both gases are released within the vitreous chamber as a solution, there should be no increase or decrease in the alkalinity of this fluid, in that both the hydrogen and the oxygen gases are broken down an equal amount and theoretically should reunite to form a same amount of water. The fact, however, that one electrode lies within the vitreous and the other one outside of the scleral shell accounts for the difference. The value of the surgery depends upon the electrolytic effect of the cathode and the reaction of the tissues to this. Von Szily and Machemer believe that the irritative action on the choroid is obtained principally by the chemical

[1] Am. Jour. Ophth., Lancaster Testimonial Issue, Series 3, vol. 26, No. 5, May, 1943.

[2] Detachment of the Retina, Treatment With the Electrolysis Needle, read before the Swiss Ophthalmological Society, May 5, 1934, Society of Physicians of the Canton Zurich, July 3, 1934.

[3] Arch. Ophth., vol. 12, No. 6, December, 1934.

action of the bodies freed by the electrolytic phenomenon at the point of electrolytic approach.

In the surgery using negative electrolysis, the sclera is carefully bared as in previous techniques, and the cathode or negative pole, as a very fine needle, is passed through the sclera in the region of the rent, at the same time observing the position of the gas bubbles as they appear through the retinal tear. In this way, the position of the needle is corrected as it is necessary so that it just passes through the retina at the edges of the tear. The current used is from 1 to 1.5 milliamperes, and the needle is both passed and withdrawn with the current closed. The anode ball should be placed on the eyeball with the current on before the cathode needle is introduced so that new and artificial holes will not be produced in the retina by the penetration of the needle. Arruga feels that it is best to turn the current off as the electrode is being withdrawn. According to Gonin, the advantages of this procedure are: its simplicity, for any simple apparatus for continuous galvanic current is sufficient; the easy ophthalmoscopic observation of the gaseous bubbles formed; the scanty loss of subretinal fluid; and the production of the heat uniformly throughout the point of the needle.

It is quite likely, with diathermy as well as ignipuncture, that the amount of heat which is developed is greater at the base of the electrode than at the point of the needle, while with electrolysis, the electrolytic phenomena occur at the points of the needle and uniformly throughout the introduced portion of the needle. Recently, from conversations with various men working actively with both negative galvanism and with diathermy, opinions seem to be developing that tears are best handled when rimmed about with catholysis, the remaining portion of the therapy being continued thereafter with diathermy.

Bipolar electrolysis of von Szily and Machemer is done with an electrode having two terminals each 1 millimeter apart. The anode is blunt, the cathode is longer and is pointed for perforating the sclera, though they also use bipolar surface electrolysis, without scleral perforation, somewhat similar to the technique of Larsson. Their penetrating electrode is applied for five seconds with an intensity of 200 milliamperes covering completely the area which needs treatment. Von Szily and Machemer advise drainage of the subretinal fluid by means of one or more galvano-cautery punctures or by diathermy punctures. Their surface bipolar electrolysis is carried out with a current of 30 milliamperes and the electrode is applied at each place for a period of ten seconds. Vogt calls attention to the fact that the surface electrolysis of von Szily and of Machemer is not to be considered as true electrolysis. The amount of current which is necessary for their bipolar therapy is the one single factor against its more general use. Von Szily and Machemer[1] up to the time of their report treated 31 patients, in all, 40 operations, with their bipolar electrodes. Eighteen cases were completely cured with excellent visual results; in 9 no improvement whatsoever was noted. In their experimental work with the electrolytic treatment of retinal separation using the cathode current, they felt there was a diffuse inflammation of the entire choroid when the unipolar perforating electrode was used, but that with the bipolar electrode this reaction was localized. Von Szily and Machemer were unable to state why the use of

[1] Klin. Monatsbl. f. Augenh., 86, 191, 1930.

the unipolar electrode produced this generalized reaction, though they believe they cause smaller scars and do not disturb the retina and the vitreous; this in spite of Vogt's contention that their surface treatment is too diffuse.

Vogt[1] is quoted verbatim as to this therapy of his:

> This new operation does not produce cicatricial bands in the retina and secondary holes from too intense heat. In contra-distinction to diathermy, cathode electrolysis is active at the point of the needle, and thereby avoids the danger of perforating the detached retina and producing new holes without cauterization. The formation of gas bubbles at the place of puncture facilitates ophthalmoscopic control of the position of the puncture during the operation. The scars are delicate. Dozens of momentary punctures can be made without damage. Any electrolysis apparatus which is used in epilating cilia is sufficient, but the needle must be very fine. As no vitreous is lost, a number of holes and tears may be treated at the same sitting. This method is not only unusually delicate, but quite efficient, and my results lead me to believe that it will rapidly replace the heating and alkali methods as well as diathermy

The best indications for cathode therapy are those cases of retinal separation with spontaneous vitreous hæmorrhage. Marshall called attention to the fact that, in these instances, as little surgery as is possible should be carried out, the important thing being the sealing of the tear and not the demand for extensive subretinal drainage. Vogt feels that catholysis has a very great value in the treatment of holes in the macula. There is no doubt that Lindner's technique of subchoroidal elevation and the injection of an alkaline solution also results in a reattachment and closure of a macular hole, but the impairment of vision which follows this is much more severe than is that impairment which follows surgery at the macula with catholysis.

Walker[2] uses for electrolysis:

> A needle .004 inch or about 0.1 mm. in size, it is from one-half to one-third the diameter of the ordinary high-grade, fine epilatory needle at a distance of from 3 to 10 mm. from the point. The shafts of the epilatory needles taper throughout their lengths, and, as a result, under the same pressure they will stop in the sclera at a different depth under a muscle where the sclera is thin than where it is thicker. If these needles are ground down to the desired condition of almost parallel sides, and from 0.005 inch to 0 006 inch in diameter, a stop can also be formed at any distance from 3 to 12 mm. from the point, Thus a set will be obtained of several different lengths from tip to stop; these can be placed in prepared tubular glass cells. The latter, in turn, are held firmly in spring receptacles, numbered as to length around the circumference of a container in such a way that the single opening in the rotary cover can expose only one needle at a time for removal, whereas all the others are prevented, by the unperforated portion of the cover, from slipping out of their cells. The entrance of each glass cell is fused into a smooth, rounded, doughnut shape, so that the extremely sharp needle tip passes into the central opening with minimal, if any, dulling if it should touch the glass. Immediately after each operation, all used needles are carefully burnished and if necessary resharpened.

In using needle electrolysis, Walker repeatedly broke the steel depilatory while inserting them into thick tough sclera, but never while removing them. Breakage, he feels, can be avoided by changing to 25 per cent iridium platinum needles or by taking a series of short holds on the needle. This procedure might be referred to as "stepping the needle in." Walker's trocar needle is an arrangement wherein an extremely fine (0.003 inch to 0.004 inch) 25 per cent iridioplatinum needle—

[1] Arch. Ophth., vol. 12, No. 6, December, 1934.
[2] Am. Jour. Ophth., Ser. 3, vol. 19, 1936.

is held in a pin-chuck without soldering and prevented from bending and also be made adjustable as to penetrating length by means of a mechanism that moves it within, and protrudes it from, a tubular sleeve, after the manner of a trocar and cannula. For instance, a sufficiently long needle, held in a pin-chuck which displaces the piston of a hypodermic syringe, may be made to fulfill the requirements with a twenty-three to twenty-five gauge stainless steel hypodermic needle acting as the sleeve or cannula. The usual sharp end of the hypodermic needle allows too much side opening. A special tip is formed, shorter and with two very sharp tips or spurs. These two sharp spurs, when pressed upon the sclera lightly, prevent any slipping while the trocar needle is making its puncture through the sclera and is drawn entirely out again. However, if the tip should accidentally slip and bend the needle, it can be straightened immediately with the fingers and, unless very acutely kinked, will continue to work as well as ever if sharpness has not been lost. Although this device is still in crude form it performs the localization by tracer bubbles and a major part of the treatment satisfactorily, because the sclera does not seem to lose fluid and vessels bleed scarcely at all when punctured with this extremely fine practically non-tapering needle. The slight current loss from needle to cannula does not in any way affect the meter reading but, on account of the diminished surface area of the needle, a full 1 mm for one second dose is used. None of these needles have ever broken even when severely bent.

Recapitulation of Basic Principles.—A review of basic principles is always welcome, especially following the intensive presentation of a complex subject. Thorpe[1] offers the following as the review of his principles.

Operation proper.

1. Anesthesia: general or local may be used. Local anesthesia is preferable.
   a. Topical—pontocain 1 to 2 per cent—four instillations.
   b. Subconjunctival and retrobulbar injection of procaine 2 per cent with 1 drop of 1/1000 adrenalin per cubic centimeter.
2. Instruments.
   a. Diathermy apparatus—criteria for strength and quality of current. This can be determined by using the weakest blended (cutting + coagulating) current with which 3/10 mm. thick pins can be inserted in the sclera. Use bipolar current with indifferent electrode under patient's shoulders. The writer's first work in 1933 was done with unipolar tube machine of own design. The results were less favorable than with present technique.
   b. Pins. The writer uses 3/10 mm. thick pins in preference to the thinner ones generally used. Pins are 1.8 mm. long for use over bullous areas, 1.2 mm. long for use over flat areas, thin sclera and in neighborhood of ora serrata.
   c. Surface diathermy tip 1½ mm. in diameter in preference to larger Larsson ball tip.
   d. Trephine for sclera is used only in thick sclera and when pinhole drainage is insufficient.
   e. Lacarrère or other forms of thin perforating needles. NOTE. Their use is inadvisable and, in general, contraindicated, for subretinal fluid should not be allowed to escape until all the punctures are made. This is difficult to accomplish with the above. Moreover, the percentage of recoveries is lower. The writer gave up their use in 1937 with some other changes in technique. The result was a rise in percentage of recoveries.
   f. General ocular surgical instruments, etc., *viz.*, blepharostat, 2 conjunctival forceps, 1 small dissecting and 1 Stevens tenotomy scissors, 2 muscle hooks, 6 single and 4 double-armed braided silk or nylon sutures, .006 inch thick, 4 conjunctival sutures single armed, .004 inch thick, 3 needle holders, 1 Worth's or other muscle forceps, 2 broad bill or Graefe's fixation forceps, millimeter rule, calipers, diathermy forceps for inserting micropins, 2 flat monel metal retractors 12 mm. wide, Arruga's retractor, 6 small serrafine forceps, 1 canaliculus dilator, ophthalmoscope, 5 per cent gentian violet in 20 per cent alcohol with toothpicks for marking meridians and outlining field of operation.

[1] Personal communication and presented, at the request of the author, as a further consideration of this subject from a fresh standpoint based upon an extensive experience.

h. Do not use excessive current or voltage. Avoid tissue destruction by prolonged current application. Determine dosage on pig's cornea and establish setting for apparatus. The writer has found that ammeters in high frequency do not register accurately the amount of current used.
i. Get good exposure of the surface of the globe with conjunctival incision and section of appropriate muscle tendon
j. Use the ophthalmoscope to check location of first micropin.
k. Make sure that all subretinal fluid is drained off.
l Work from the fundus sketch with a preoperative working drawing having thereon the calculated positions of the separation and tears or holes in retina.
m. Have patient use Lindner's round-hole, stenopaic spectacles immediately after making diagnosis and for two to three months after removal of bandages.

Vogt,[1] in discussing the complications connected with catholysis, calls attention to several points worth repeating here. In high degrees of retinal detachment wherein catholysis is being utilized, drainage of the subretinal fluid with a lancet or with a large needle may result in loss of vitreous before the subretinal fluid itself flows from the eye. This is *serious*. Another point to which he calls attention is the fact that when catholysis is being used, early subretinal drainage may so change the position of the separated retina that the scleral projection of the retinal tear has also changed its position grossly. This is to be guarded against by careful ophthalmoscopic examination. The greatest complication connected with catholysis, however, is damage to the cornea from local anesthesia or because of blood rendering the essential adequate ophthalmoscopic control impossible.

Miscellaneous.—The injection of air into the vitreous has been mentioned several times as a valuable procedure. In the handling of large gibbous folds and bulges, one may seriously consider the injection of a few centimeters of air through the sclera after coagulation therapy and drainage. The point of the needle is directed toward the center of the eyeball posteriorly, away from the lens and 2 to 3 cc. of air are slowly injected to fill a collapsed hypotensive globe and thereby assist in subretinal drainage and reposition of the retina.

Many cases of traumatic retinal separation of an extensive degree can be conserved with fair residual vision, if it is possible to seal off that entire portion of the retina separated and torn, by a line of diathermy coagulation along the margin of the intact retina. Such instances can be assisted in subretinal drainage and the reapplication of the retina through air injection. The patient will have a large sector defect remaining in his field of vision, due to the fact that the entire retina from the line of punctures to the periphery has been deliberately thrown out of use, but the separation will be halted in its progress and that portion of the retina still attached and normal will remain so.

Scleral Resections.—In the section under scleral surgery, the matter of partial scleral resections was considered. It is relevant to refer to it again at this point, simply to make this surgical subdivision complete. Ramach[2] reported the results of 12 such operations, as done by Lindner. Strips of sclera from 2 to 6 mm. in width were resected in the region of the equator,

[1] Die operative Therapie und die Pathogenese der Netzhautablösung, Verlag Enke, Stuttgart, 1936
[2] Arch. Ophth., 133, 321, January, 1935.

this being done in two stages. The sclera was thereby shortened more or less evenly in all meridians. The palpebral fissure became narrower, and the apex of the cornea receded slightly. The curvature of the cornea was always altered by the operation. Sensitivity of the cornea was temporally restrained and the anterior chamber became more shallow. Brown[1] operated on 2 such instances with Lindner in 1935. Only one-half of each eye was operated; the anatomic results, *i. e.*, reattachment of the retina, were good. One case had a large field with 0.4 vision, and the other, after eight previous operations, developed a quiet retina with 0.1 vision. Ramach feels that in all cases of retinal separation with an unfavorable prognosis, Lindner's recommendations are to be seriously considered.

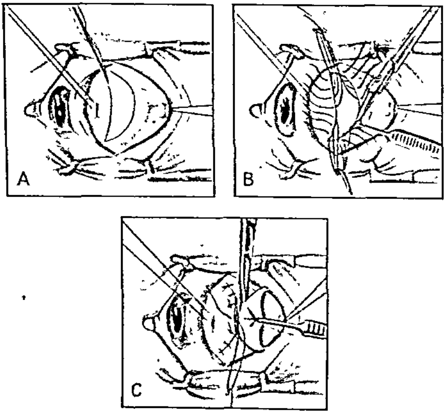


FIG 500 —Scleral resection for high myopia or myopia with retinal separation modified after Borley *A*, external rectus retracted, scleral segment for resection outlined, *B*, sutures placed prior to the removal of the scleral crescent; scissors and forceps in position for resecting the sclera without cutting the sutures; *C*, completion of segment removal; sutures are tied progressively so that the incision is closed as the scleral sector is removed.

He feels, as quoted by Borley[2] that the use of the shortening operation is to be restricted only to cases of aphakia in which the common operations have failed. Lindner expressed the belief that the greatest shrinkage of the vitreous occurs in these cases. If this is so, there is no doubt that the technique as outlined by the author, page 528, and more recently by Borley, (Fig. 500) are to be seriously considered. Borley stated that cases

[1] Year Book, Eye, Ear, Nose and Throat, p. 105, 1935.
[2] Arch. Ophth., vol. 23, No. 6, June, 1940.

of myopia with separation, or those in which marked retraction or shrinkage of the vitreous is suspected appear to offer the best prognosis after a

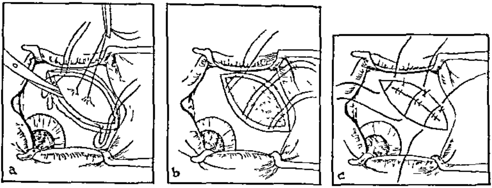


FIG. 501.—Vail's resection of staphyloma. Traction sutures (a) permitted the elevation of sclera and its removal; in (b) the sclera is closed with mattress sutures two of which were placed *before the complete removal of the scleral section*, and (c) conjunctival sutures

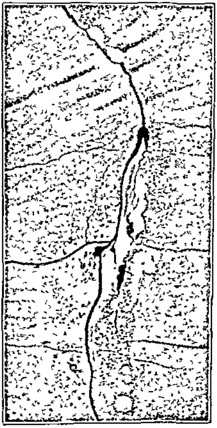


FIG. 502.—Fundus picture of Vail's case, showing the quiet, flat choroidal scar. (Vail, courtesy of Am. Jour. Ophth., Series 3, vol. 24, April, 1941.)

shortening operation, particularly if no hole is found, or if prior surgery for the separation has brought about no improvement.

Vail[1] discussed this matter in its relationship to the excision of a staphy-

[1] Am. Jour. Ophth., Series 3, vol. 24, No. 4, April, 1941.

loma in the presence of retinal detachment and presented a case with a complete and uneventful recovery following this operation. Sketches of his technique as he presented it follow herewith. (See Fig. 501.) The photograph of the fundus following recovery, Figure 502, is especially interesting.

POST-SURGICAL TREATMENT

This may be considered under two subdivisions, the immediate, *i. e.*, for the first month, and the later, to include all time thereafter.

Postoperative immobility of the eyeball is absolutely essential. Under ordinary circumstances, the patient will keep his two eyes quiet under a binocular postoperative dressing. If the surgeon, however, fears that his patient will not be quiet, he can obtain absolute fixation of the eyeball by passing a double-armed suture through the inferior rectus muscle under the conjunctival cul-de-sac of the lower fornix and out through the lower lid. The two ends are then threaded through a large pearl button and tied to hold the eyeball completely immobile. If the inferior rectus muscle has been detached, to give satisfactory exposure for the surgery, it would be unwise to use such a fixation suture; the external rectus can be utilized equally well. Arruga passes his sutures through the inferior rectus and through the lid with the suture lying exposed in the conjunctival cul-de-sac. In passing the suture subconjunctivally, it must be done before the conjunctiva has been closed, at the end of the operation. Atropine must be instilled after the operation and a binocular dressing applied. The dressing should be so arranged that there is no direct pressure upon the eyeball. This can be obtained by building up a horseshoe- or ring-shaped compress of resilient cotton about the bony configuration applying thereon a 4 × 4 piece of folded gauze and the protective dressing, (as a Ring mask) above this. A simple metal shield is not adequate, in that this does not eliminate the light which the patient would be aware of even through the closed lids.

Pain and restlessness should be combated by sedatives. The head should be placed in a position most beneficial to drainage, *i. e.*, if the operation has been performed in the superior portion of the retina, the head should be as low as possible even to tilting the foot of the bed upward. Some patients cannot tolerate this position, and the surgeon should take cognizance of this. If the operation has been performed in the lower part of the retina, the patient may have high pillows, or even a back rest. A case with a hole in the macula should be in a prone position. The lateral situation of the separation should also be considered, and the patient placed with his head to the right or the left side depending upon whether the nasal or the retina was involved. With old patients, absolute immobility is not only inadvisable, but is contraindicated. These individuals should be turned from side to side, the upper part of their body raised and lowered at various distances, and they should be given passive exercises daily to all four extremities. Breathing exercises for a few minutes at hourly intervals are of definite value. As Arruga said, "the chief need is rest of the operated eye. It is not necessary to torture the patients." Acute urinary retention must be prevented in patients with hypertrophied prostates. Elimination from the bowel should be started on the second postoperative day by mild cathartics and a low enema. Naturally, these patients are strict bed patients and must utilize bed urinals and bed pans.

The strict postoperative period varies somewhat in patients. It should never be less than six days and probably should be, in the major number of patients, from fourteen days to three weeks; after that they may be moved about a bit more in bed so that shortly after the third week they are sitting up fully in bed. An ophthalmoscopic examination should not be done before the sixth day. The first dressing may be done on the second day, atropine instilled, the cul-de-sac cleansed of its secretions and the dressing applied as before. After the sixth day, it is not necessary to continue with a special dressing. It still should be a binocular dressing but ordinary occlusive eye pads with a protective mask are sufficient. On the sixth day the fundus may be examined. If it is gray with multiple vitreous opacities, the postoperative convalescence will be delayed. If the fundus is red, however, and the retina back in position, the patient may be allowed liberty a bit sooner. The sutures can be removed from the tenth to the fourteenth days, hot compresses and irrigations started to hasten recovery from the postoperative reaction, and at that time pin-hole glasses should be ordered. While the patient is in bed, his meals should be light and almost entirely meat free. Additional surgery, if it has been anticipated, can be carried out any time after the tenth postoperative day. Naturally, this applies only to those cases wherein it was known that one operation would be inadequate. Reoperations because of unsatisfactory results should be delayed until after the third week. If there has been no recovery after four weeks, the surgeon will rather likely feel that the case has resulted in a failure and may then consider additional surgery. Some instances do show good results, even as late as this, and it may be wise to consider some delay and permit the patient to be about for several more weeks with his pin-hole spectacles, keeping the eye atropinized. Gradle and Meyer[1] described one case in which the retina became entirely flat three months after the operation. Empirically, they feel that the second operation should not be done until at least two or three months have elapsed after the first. Reoperations, because of earlier unsatisfactory results, cannot be done before the disappearance of the inflammatory signs resulting from earlier surgery. In spite of this wait, the conjunctiva and Tenon's capsule will be adherent, the muscles will be detached with difficulty, and there may be a distressing amount of bleeding in the field of the operation. The atropinization, the compresses, and the irrigations are to be continued until the eye is white. The operator should be careful to prevent the development of any iritic synechiæ. During this period of convalescence, small doses of the iodides seem to be of benefit in cases with a slow recovery. It is proper, therefore, to use them. In general, one must not place too much confidence upon a cure until the patient is up and about. In the final analysis, the major number of late complications appear only after the patient has been permitted to resume a fair percentage of his former activities.

The late postoperative treatment of these cases depends upon their disposition, their occupation, the degree of retinal separation which was present, and the operative results obtained. As soon as the eye is white, the pin-hole glasses can be discarded and the patient permitted to wear his ametropia correction. These lenses should be frosted throughout, except for 0.5 cm. aperture for the first three months of the postoperative

[1] Am. Jour. Ophth., vol. 19, No. 10, October, 1936.

period. After that, the aperture can be changed to 1 cm., and these glasses worn constantly for a year. It might even be necessary at the end of six months to change them the third time and increase the aperture to 1.5 cm. This portion of the late treatment of retinal separation has been neglected. The value of the glasses lies in preventing the constant shaking of the vitreous which accompanies the lateral up and down movements of the eyeball, as was demonstrated by Lindner in his flask preparations of gelatin. Movement of the head itself does not cause this vibration of the vitreous. The frosted glasses minimize rotations of the eyeball compelling the patient to move the head instead of the eyes. It is remarkable how the patient will adjust himself to them within a period of from six to eight months and compensate with movements of the head.

In speaking of these frosted lenses for patients with retinal separation, Berens[1] stated that the advantages of these lenses are: that they are less conspicuous than the lenses usually prescribed for patients with separation of the retina; they contain the patient's ametropic correction; are no more expensive than ordinary lenses; and the patients wear them much more willingly than they do the various other disk glasses and goggles which have been recommended. (A similar lens has been recommended by Lancaster in Boston.) The author has seen a recurrence of a retinal separation two days after the discontinuance of their use, a total of thirteen months after apparently successful surgery. The incident is mentioned to emphasize their value, and also is a proof of their efficiency in their purpose.

Bifocal lenses cannot be ordered in these frosted lenses. For reading purposes, the patient should have his presbyopia addition ground in a hook front to be snapped on over his constant wear glasses. Even after an immediate full and satisfactory recovery, these cases should be kept under constant observation for the first year so that complications, if they develop, can be promptly combated.

The postoperative management of Thorpe[2] is as follows:

1. Position in bed. Have patient lie on side or semi-recumbent so that previously separated area is dependent. Do not elevate foot of bed when separation is above, since doing this for any length of time makes the patient restless. This restlessness may be associated with ocular movements and result in a poor prognosis. If necessary allow old people out of bed in two or three days.
2. Diet.
   - *a*. Liquids during first twenty-four hours.
   - *b*. Dehydration either before or after operation is unnecessary.
   - *c*. Soft diet for two days. General diet thereafter.
3. Medication.
   - *a*. Codein sulfate ¼ to ½ gr. for pain at intervals of three hours if necessary.
   - *b*. Seconal, 1½ gr., as sedative for two nights.
4. Bowels.
   - *a*. Enemas at intervals of two days if required.
   - *b*. Mineral oil, 1 ounce, for several days at bedtime.
5. Dressings.
   - *a*. First dressing four days postoperative. Instil atropine 1 per cent in operated eye.
   - *b*. Thereafter dress every two days and instil mydriatic (atropine 1 per cent or scopolamine 0.2 per cent).
   - *c*. Keep both eyes bandaged for four weeks.
   - *d*. Remove sutures at end of three weeks.
   - *e*. Watch tension with fingers.

[1] Trans. Sec. Ophth., Am. Med. Assn., p. 275, 1936.

[2] Personal communication.

6. Examine fundus at end of eight to ten days postoperative.
7. Allow out of bed at end of three weeks (aged patients are allowed up sooner).
8. Apply stenopaic hole spectacles at end of four weeks Cover one opening to avoid alternation of the eyeballs.
9. Allow to go home at end of four to five weeks with restrictions on exertion of any type. Prohibit reading for three months or longer

Comment: The patient should understand that rotations of the globe predispose to separation and interfere with a good result.

Complications.—These can be subdivided into immediate and late. The immediate complications are: (1) severe hypotension; (2) hæmorrhages, (*a*) massive vitreous hæmorrhage, (*b*) minor retinal hæmorrhages; (3) vitreous prolapse; (4) postoperative keratitis; (5) postoperative iritis; (6) infectious conjunctivitis and tenonitis; and (7) unusual and extensive postoperative reactions.

The late complications are: (1) vitreous opacities; (2) cataract formation, (*a*) immediate, (*b*) late; (3) operative failures and a recurrence of the separation after a period of apparent recovery; (4) hypophoria or hyperphoria; and (5) extensive chorio-retinitis, pigmentary deposits, retinal striation and the formation of proliferating bands.

Severe hypotension is of importance for several reasons Its premature development makes it necessary to limit the surgery in any one case. It interferes with satisfactory subsequent postoperative subretinal drainage, and in these instances, there is always danger of a cataract developing. The best way of combating it is to prevent its development, as much as is possible. In the therapy with the micropins of Walker or the single and double electrodes of Šafář, subretinal seepage can be prevented until the entire involved area has been treated. With scleral trephining, care must be taken to prevent perforation of the choroid until all trephining openings have been cut. The surface therapy of Larsson results in hypotension by reason of the surgery and this cannot be prevented. It may make difficult the subsequent necessary areas of electrocoagulation for drainage. Therapy by the fixed-handle adjustable electrodes of Weve, Meesmann, and Lacarrère will result in early subretinal drainage, and this surgery must be carried through as rapidly as is possible to minimize hypotension. Retrobulbar injections, of novocain and adrenalin for anesthesia, lower ocular tension, hence should not be used. A moderate degree of hypotension can be combated by supporting the sclera under treatment with toothed forceps either applied directly to the sclera by fixation, or applied to the intact recti muscles.

Minor retinal hæmorrhages, which are not uncommon, are probably no factor in the end-result. Massive retinal and vitreous hæmorrhages, however, are a serious complication, in that they may result in ocular hypertension or be so extensive that by their very presence the visual results are completely nullified. Severe retinal hæmorrhage, into the vitreous, may occur in those cases where a retinal vessel crossed the retinal tear. Greeves[1] described one such case. Greeves, in presenting his case, also spoke of the probability of a spontaneous vitreous hæmorrhage being due to the retinal separation itself. A case of vitreous hæmorrhage cannot be too carefully watched, so that if retinal separation is developing, the true diagnosis may be made as early as is possible. A similar case presented itself recently

[1] Trans. Ophth. Soc United Kingdom, 56, 148, 1936.

wherein a most extensive vitreous hæmorrhage resulted in a child from the explosion of a large fire cracker. Five months after the accident, the vitreous had cleared sufficiently so that one could see a large flat temporal separation, with a disinsertion which involved the entire temporal half of the ora serrata. Marshall, in discussing the therapy of these cases of retinal separation with vitreous hæmorrhage, emphasized the fact that in such instances as little surgery as is possible should be done; the sealing of the tear alone is sufficient, without insisting upon extensive subretinal drainage. In spite of such hæmorrhages, the postoperative treatment should be carried on just the same, in that, in many instances, a remarkable amount of absorption can and does occur in those cases. The iodides and dionin are to be used. It is rather likely that minor subretinal hæmorrhages, choroidal hæmorrhages, and vitreous hæmorrhages are in part the cause, in some instances, of severe vitreous clouding; the opacities in the vitreous themselves not being hæmorrhagic. Thrombosis of a vortex vein has been reported as a postoperative complication, though very rarely. Two or three days after an operation, according to Black,[1] there was an intense chemosis and aching of the eye. At first there was only a faint fundus reflex. There were, however, no inflammatory signs, and the congestion and chemosis, which lasted for several weeks, appeared to be obstructive in origin. At first there was little more than light perception. There was slow improvement, the retina taking on more normal appearance and the detachment becoming more shallow. The vision improved to 3/36 when last seen, and there seemed to be some chance of further recovery in the case. Probably the complication is more likely after scleral trephining rather than after a more localized form of treatment as would be used in electrocoagulation. It is fortunate that many holes are well forward and the risk to the vorticose system thereby slight, but in every patient, one must be very careful of these vessels.

Vitreous prolapse should not occur except after ignipuncture. Naturally, it is certain to occur then. It may follow a scleral trephining—but not necessarily nor desirably so. Occasionally a vitreous fistula is deliberately planned, but under all except extraordinary circumstances, prolapse of the vitreous is neither necessary nor desirable.

Iritis and keratitis, if they develop, are the result of the operative traumatism and occur from gross hypotension, unnecessary and overenthusiastic diathermy treatment, and from damage to the ciliary body by reason of the electrodes. An exposure keratitis *intra-act* may occur with denudation of the corneal epithelium. This should not be of any serious import.

Infectious conjunctivitis and tenonitis should not occur if the preoperative medication has been properly handled, and the operator has maintained asepsis. Occasionally, an unusual and extensive amount of postoperative inflammatory reaction appears. As long as this is not bacterial in nature, the operator need not be especially concerned about it. It may be wise to start hot sterile compresses early in the postoperative course, adrenalin chloride instillations and irrigations of warm saline boric acid or warm 1 to 10,000 aqueous metaphen solutions, but the reaction recedes fairly rapidly and uneventfully.

The development of extensive vitreous opacities is rather common, and not well understood. At times, this condition appears quite unexpectedly

[1] Trans. Ophth. Soc. United Kingdom, 52, 499, 1932.

and in the presence of a minimum amount of surgery. It seems to be most common in patients in poor general health, with diabetes and in the older patients. It is quite possible that extensive surgery and the development of serious hypotension are also factors. Minor hæmorrhages into the vitreous and choroidal hæmorrhages are almost certainly a cause; also, the longer established the case the more probable is it that these will develop. Retinal separation from traumatisms and reoperations for retinal separation also show this complication in a larger proportion of instances. Iodides should be used, subconjunctival injections of hypertonic salt solution and dionin. In some cases, these opacities clear up entirely; in others they may remain to such a degree that one has great difficulty in seeing fundus details.

The immediate postoperative development of a cataract is due probably to too extensive surgery or to direct injury to the ciliary body or the lens itself. A case, which was operated by the author, in the presence of old posterior synechiæ, early developed cataract formation; and in this instance there was no damage to the ciliary body, and the surgery itself was not extensive. According to Arruga,[1] when the lens opacity appears several months after operation, in patients of advanced age, it may be a senile cataract developing prematurely as a result of ocular disorders, following the separation of the retina, or from its treatment. The conduct to be followed in such instances depends upon the condition of the fundus If the retina seems to be reattached, depending upon the field of light projection, there is no reason to withhold operation, always taking into consideration that loss of vitreous is most unfavorable in these cases. Cataracta complicata is an almost universal complication wherein the surgery has been unsuccessful. The lens changes in these instances appear from two to six months after the operation, and progress so slowly that the operator can follow their course and development and know thereby the correct etiological factor. Removing the cataract is of no assistance In all probability the eye is hopelessly lost. These instances of cataracta complicata are the almost certain indication of failure from the surgery.

A muscle imbalance following the surgery is an unfortunate complication, though it is uncommon. Accurately coapting the detached muscle and its stump should minimize these cases to an almost negligible incidence One must not confuse the metamorphopsia of retinal separation with a true hyperphoria. Satisfactory muscle sutures should prevent its development in all but a few unusual instances. Should it occur, there is nothing that one can do except to correct it surgically in the case of the lateral rotators, and to utilize correcting prisms in those instances wherein an elevator or a depressor is involved. Instances may arise wherein surgery is even necessary upon an elevator or a depressor. It is probably better to tuck the weakened or involved muscle rather than to recede the intact overacting muscle. Each case, however, must be considered according to the symptoms which are present and the degree of imbalance remaining as a permanent defect.

REOPERATIONS

Reoperations because of preceding failures, are difficult procedures. Tenon's capsule is adherent to the formerly treated sclera, muscle adhesions

[1] The Treatment of Retinal Detachment, English translation, Barcelona, Castrovejo, 1936.

have occurred, and the conjunctiva may show some shortening from the former surgery. The operator should satisfy himself in each instance, that the recurrence or the failure is not due to retinal tears which had been overlooked and which thereby escaped treatment. It may be necessary to go over the entire ground again as in the former surgery, resealing a hole and arranging for subretinal drainage. Failures and recurrences must be handled, in so far as therapy is concerned, as if they were being originally operated. One cannot depend upon late results from previous surgery. It does seem as if these operations for recurrences are responsible for the major number of iridocyclitis complications and the relatively few instances of early cataract formation. Perhaps the complications are only a part of the pattern indicating the complete failure, rather than purely a complication from the surgery. Regardless of their true relationship, they must be prevented if it is possible. In so far as recurrences are concerned, the patient should be warned against minor traumatisms, for his pinhole glasses and the frosted central-aperture glasses restrict the field of vision to such a degree that head injuries are not at all uncommon in these individuals, and it is necessary to guard against such accidents.

Extensive chorio-retinitis, pigmentary deposits, retinal striations, and proliferating bands are all occurrences which appear during recovery, are apparently connected with the operative chorio-retinitis, the coagulation of tissues, the reaction to this tissue damage, to small hæmorrhages within the vitreous, and are undoubtedly modified by a preëxisting degenerative retinosis which may have been present. The retinal striation one sees seems to indicate "lines of re-attachment" and has been described previously as "wave marks on the sand outlining the highest point of the tide." (Evans.) In the final analysis, one is surprised, not at the many retinal changes which seem to occur, but at the very few which develop considering the surgical damage to the choroid and the retina from those means utilized to seal the hole, to develop an adhesive choroiditis, and to arrange for satisfactory subretinal drainage. These three points are the reason for the surgery which has just been outlined, and they must be carried out adequately, though at the same time, without unnecessary damage to the tissues.

CHAPTER XXVI

TRAUMATISMS OF THE GLOBE AND LIDS—PERFORATING INJURIES OF THE GLOBE—SYMPATHETIC OPHTHALMIA. INTRA-OCULAR FOREIGN BODIES; MAGNETIC AND NON-MAGNETIC

TRAUMATISMS OF THE GLOBE AND LIDS

TRAUMATISMS of the globe are to include molten metals, acid, and alkali burns. The other traumatisms which can and do appear have been discussed in their proper subsections.

Third degree burns of the lids by a blast of flame or other explosive effects, calls for immediate débridement and subsequent protection dressings. Primary repair with skin graft is permissible, but such repair with pedicle flaps is proper. (See Fig. 503.) (See section on Lid Repairs.)

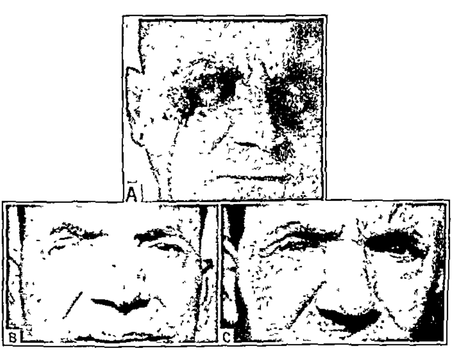


FIG. 503.—Eyeball trauma and lid destruction from airblast and impact following the explosion of a grinding wheel. Immediate débridement; suture of remnants of lid surface and conjunctivæ, free skin grafts from the opposite lid to fill in the lost skin. (b) condition after intermarginal adhesions, awaiting healing; (c) new palpebral fissure, cornea partly leukomatous, some photophobia still present.

The treatment for second and third degree burns of the lids and the soft tissues of and about the orbit is somewhat dissimilar to that for second and third degree burns in other parts of the body. *Unfortunately most oph*thalmological burns are a part only of a more generalized and a more extensive burn of the face and the upper part of the chest. *There have* been many changes in recent years in the treatment of second and third

degree burns, in fact the treatment in general is still very definitely in a state of flux. The shock and the toxemia must be combated by blood plasma injections and whole blood transfusions. The loss of proteins is definitely outstanding in extensive burns. The normal 6.5 per cent of protein nitrogen may drop as low as 3.5 and even to 3.2 per cent without death. This, however, is a fall to a grave degree. It must be corrected by additional feedings of meat proteins, amino acids, and milk proteins.

The sulfa drugs are indicated in many instances in addition. It seems as if the local application of triple aniline dye to the soft tissues of the lids and about the orbit is the most satisfactory of the local applications. Tannic acid application and the various paraffin sprays are not especially well adapted to the treatment of lid burns.

Conjunctival burns, especially those from hot metal and from flashes, should have mucous membrane grafts for repair as early in the treatment of the case as is possible. Free skin grafts for the replacement of lost tissue can be delayed at times until healing has occurred. It is, however, necessary to protect the cornea in these cases from exposure. This will in many instances modify the time best selected for the use of epithelial grafts and the correction of recent ectropion from such burns. Inter-marginal adhesions from an intact lower lid to a contracting upper lid may be sufficient for the protection of the cornea until the time for grafting is optimum, depending upon other attendant circumstances. (See Fig. 503, *B*.)

Molten metals include melted lead, molten iron splashes and glowing iron sparks, electric current burns, molten solder, and other soft alloys, and hot cinders. The degree of trauma and the position of the burn on the globe decides the procedures to be applied. A through-and-through burn of the sclera does not demand enucleation unless the eyeball is collapsed or the extent of the burn so wide that there is no possibility of subsequent cicatrization and recovery. Destruction of the anterior segment of the globe means blindness with secondary glaucoma from the traumatic iridocyclitis, and the sooner an enucleation is carried out, in these instances, the more rapid will be the convalescence. Perforation of the anterior segment indicates an almost hopeless condition. In cases where the major portion, or all of the burn, involves the lid and the conjunctiva, the solidified metal should be removed with forceps, if possible, and if the degree of injury permits, an immediate débridement done of the burnt tissues, with subsequent primary suturing. The fluoroscope and especially the biplane fluoroscope are necessary in some of these cases. The wounds are sterile primarily and if they have been properly attended at the time of the emergency treatment, they should continue uninfected. The sequelæ of these injuries are symblepharon, entropion and ectropion, pseudopterygium, destruction of the lids themselves, and the loss of the eyeball. If the damage is of such a minimal degree that there is a reasonable certainty of saving the eyeball, then also is this reparative surgery necessary while the case is in an aseptic phase. The amount of subsequent complications which can be prevented and minimized is remarkable. If the eyeball cannot be saved, an early enucleation is definitely indicated. The burns which occur from lead and from solder and from antimony and other similar alloys, from zinc and from tin, are ordinarily not as extensive, in that these metals harden and cool so much more rapidly than do those

burns which occur from iron and from fused brass, from molten steel and from molten slag. In such instances, the eyeball and much soft tissue are ordinarily lost. Burns from electric current not only damage the eye and the lids externally, but also there is usually considerable damage to the retina and the macula.

Of the acids, sulphuric, hydrochloric, and nitric acid are the most common ones. Carbon dioxide or carbonic acid gas and sulphur dioxide injuries are not at all uncommon in these days of generalized refrigeration. The destructive action of these acids seems to be by far the worst with nitric acid, though sulphuric and hydrochloric cause burns which can be equally severe. *The immediate treatment is copious irrigations with water and with sodium bicarbonate solutions and the use of liquid petrolatum after all the acid has been neutralized. The peculiarities of acid burns, especially nitric* acid, is the wide-spread extent of the tissue destruction. Primary reparative surgery is out of the question. It is perhaps possible to minimize the extent of the late plastic defect by the insertion of a glass conformer during the convalescence, but if the cicatrix is extensive, it will eject this conformer during the healing, regardless of what is done. It is best to do nothing which will hinder the rate of primary recovery, and to plan for early mucous membrane graft repair of the defect. When the cornea is extensively involved in these cases, peritomy, peridectomy, and circumcorneal limbal cauterization minimizes the pseudopterygium encroachment upon the cornea. If any intact epithelium is remaining upon the cornea, this should be carefully conserved because *it is a most important factor in limiting a* pseudopterygium. Phenol and high strength solutions of cresol cause a similar destruction of the soft tissues. Fifty per cent aqueous solution of alcohol should be used immediately in these cases for neutralization of the phenol, and subsequent to that, copious irrigations of warm normal saline It is almost as difficult to remove these substances from the soft tissues as it is to remove the true acids.

The common alkalies are lime, slaked or unslaked, solution of silver nitrate, sodium and potassium hydroxide, and ammonia, and are perhaps the most common of injuries. Unslaked lime, *i. e.*, an oxide of calcium, is converted into a hydrate of calcium by its chemical reaction with water It is doubtful whether the heat *which is generated in the process of slaking* plays any great part in the trauma. The other calcium salts used in pastes and in plastering, in cement, and the alkaline effects of commercial fertilizers all act by the removal of water from the tissues, the chemical destruction of the tissues with the formation of an insoluble albuminate, and the continued penetration of the tissues by the alkali, and perhaps in part by thermal destruction.

The physical and chemical alteration of the tissues, as Wurdemann states,[1] is the most important factor. This is especially significant with ammonia burns. Here one is not only concerned *with the direct alkali* destruction of the tissues, but also with the penetration into the eye tissues *of the NH_4OH radical and the difficulty* in rendering this chemically inert. Most ammonium salts are unstable at the best, and at the worst, they are as irritating as the NH_3 gas itself. It is rather likely that alternating copious irrigation of saturated solution of boric acid, even though its acid

[1] Injuries of the Eye, 2d ed, St Louis, C. V. Mosby Company, p 39, 1932

radical is quite stable, and ordinary soda water, H_2CO_3, are most effective as a conjunctival flush. Prechler[1] practices immediate paracentesis of the cornea for ammonia burns. He states that the ammonia appears early in the anterior chamber, continuing, thereby, destruction of tissues with grave consequences. Oil and petrolatum continue the treatment as with acids. The treatment of lime burns depends upon the removal of the foreign substance by copious irrigation with water, with dilute acetic acid, and with a 5 per cent neutral ammonium tartrate solution. This solution is especially valuable for the lime burns. Wolff[2] has recommended a 10 per cent solution as a preferred one, in that its action is the formation of a soluble calcium tartrate, assisting appreciably thereby in the removal of the alkali

The treatment of gas burns of the cornea, of the conjunctiva, and the lid as worked out experimentally for the present possible war gases (should these be used) is at the present not general knowledge. If and when such casualties appear, information in regard to the treatment will be promptly disseminated by the Medical Departments of the Armed Services. At the present time they are to be handled as are other acid or alkali burns depending upon the agent causing the traumatism.

In general, the conjunctivitis of the lung irritants and lacrimators, as phosgene, chloropicrin, chlorine, adamsite and white phosphorus, is copious irrigations with mild alkaline solutions and transfer to surroundings free from gas contamination. The commonly used tear gas, used in police work of civilian life as well as the former military gas is a mixture of chloroacetophenone, chloropicrin, and chloroform. Gifford's solution for the treatment of exposure to this is a 0.4 gm. solution of sodium sulfite in 25 per cent of distilled water and 75 per cent of glycerine.

The vesicants, as lewisite, the nitrogen mustard gases, and mustard gas (a beta-chloroethylsulfide) result in pathological changes of a much greater initial severity as well as being responsible for grave degrees of late pathology. In exposure to these, the latest report from Great Britain's Ministry of Health,[3] recommends a 2 per cent sodium bicarbonate solution if irrigation can be done within five minutes after exposure. (Water is perhaps equally valuable at this time.) Irrigations after this are of no avail and may be harmful. The lids must be opened for this. The eyes must never be bandaged. Cocaine is contraindicated. Oils and ointments should not be used until the patient has been moved from the contaminated atmosphere. Astringents are contraindicated with corneal damage. After hospitalization, solid or liquid petrolatum is to be used.[4]

Denig has been very insistent on the early surgical treatment by means of buccal mucous membrane grafts of chemical burns of the cornea and the conjunctiva. He states[5] there is no doubt that delay in the treatment of these instances means hopeless impairment of vision. According to Neuman, as quoted by Denig, blindness occurs three times as often after conservative treatment as after surgical treatment, and obliteration of the cul-de-sac five times as often. His summary is as follows:

[1] Ztschr f Augenh, April, 1910. [2] Brit. Jour. Ophth, 10, 196, 1926.

[3] Emergency Medical Service Instructions, London, His Majesty's Stationery Office, April 7, 1942, pt. 1, suppl 33.

[4] New War Gases, Training Circular No 86, Government Printing Office, Washington, D C., Nov. 13, 1942

[5] Med. Rec, 148 395, Dec. 7, 1938 p 158.

In the use of transplants (mucous membrane) for eye burns every hour counts. The operation must be immediately performed. First degree burns without lesions of the cornea may be conservatively treated, if the burn was caused by less dangerous chemicals, for instance, acids and lime. First degree burns without lesion of the cornea require instant transplantation, if they are the result of burns from concentrated alkalies, liquid gas, vapors of halogen combinations, or like dangerous chemicals. First degree burns with lesions of the cornea, even when caused by less dangerous chemicals, require mucous membrane transplantation to shorten the time of treatment and remove uncertainty in regard to the result The general practitioner should take the lines just described, and, if necessary cooperate immediately with a competent eye surgeon.

The later capacities which occur in the cornea from lime can be improved to a tremendous extent by continued treatment. Würdemann mentions Stutzer[1] recommending a 2 per cent ammonium chloride solution. Guillery[2] also uses this, at first as a wash for from one-half to three-quarters of an hour at a time, and later for the instillation of drops in stronger solutions, even up to 20 per cent. These strong solutions of ammonium chloride should not be used, however, until complete cicatrization has taken place. Würdemann's recommendation of 10 per cent neutral ammonium tartrate has been mentioned and Brown and Harrowitz[3] recommended ammonium lactate, in that they felt it has less of an irritating reaction and is almost as *efficacious in the formation of a soluble calcium tartrate. It is* wise to keep the ammonium tartrate as dry crystals in weighed amounts in empty firmly corked bottles, at hand as, for instance, in the treatment cabinet of an accident ward. When an alkaline burn presents itself for treatment the necessary amount of distilled water can be added, for the desired solution, and a fresh neutral ammonium tartrate solution thereby obtained for the case.

PERFORATING INJURIES OF THE GLOBE

Perforating injuries of the globe include: (*a*) those in which the foreign body has not been retained; (*b*) those in which the foreign body is still retained; and (*c*) extensive destruction of the globe and the soft tissue by such occurrences as mine explosions and through gunpowder and gas explosions. A discussion of perforating injuries of the globe with retention of the foreign body should also include those instances of double perforation of the globe wherein the foreign body has traversed it and now lies extraocularly, deep in the orbit.

Perforating injuries of the globe without retention of the foreign body have been discussed in adequate detail under the section on scleral surgery. The points of importance here for recapitulation are as follows: (1) the degree of vision remaining; (2) the position and extent of the wound; (3) the presence of intra-ocular hæmorrhage; (4) the position and condition of the lens; *and (5) the degree of loss of the ocular contents.*

The indicated operative therapy depends wholly upon these factors. For instance, if there is no light perception whatever present, there is also little use in attempting conservation of the globe. The position of the wound determines the possibility of a later sympathetic ophthalmia, and the size and extent of the wound is more or less an indication of the loss of ocular contents, of dislocation of the lens, of intra-ocular hæmorrhage, of retinal

[1] *Deutsch. med Wchnschr*, No 37, p 594, 1900.
[2] Klin. Monatsbl f. Augenh, 48, Suppl, p 75, 1907.
[3] Klin Monatsbl f. Augenh, August, 1923.

damage, and an opinion as to the advisability of conservative reparative surgery. Extensive intra-ocular hæmorrhage is not necessarily irrecoverable, but it is to be considered in terms of conservation. Prolapse of the ciliary body and prolapse of the choroid and the retina, demand usually an enucleation, though in some instances the prolapsed posterior uveal tract may be cut off, the wound closed, and sutured, and the eyeball saved. Prolapse of the ciliary body is almost positively a demand for enucleation. Extensive loss of vitreous means progressive phthisis bulbi, and here also enucleation is best done as early as is possible. Implantations into Tenon's capsule should be delayed, however, and inserted as late implants in these conditions.

EXPLOSIVE EFFECT IN INJURIES OF THE GLOBE AND THE ORBIT

Usually, particles of bone completely detached from the skull should be removed from the wound. Those still adherent to the surrounding periosteum should be conserved if possible. Fractures should be reduced and held in position by splints and dressings. The danger of early probing of the orbit for detached bone fragments and metallic foreign bodies has been frequently emphasized.[1] When a globe is completely disorganized the wound should be carefully searched for bits of uveal tissue to prevent sympathetic ophthalmia. Evisceration is recommended rather than enucleation because of ascending infection. The evisceration should be postponed for a few days if possible. Lids which are grossly lacerated should be sutured, even as a temporary measure, to prevent damage to an otherwise intact cornea. Sulfa drugs should be used as solutions and crystals at the time of a first dressing. Matthews mentions the implantation of sulfonamide crystals directly into the anterior chamber prior to the use of conjunctival flaps.

The explosive effect of mine explosions and of gunpowder explosions is usually serious. Soft tissues are involved, traumatic cataracts are the least complications possible, and multiple perforations of the globe are frequent. Coal is ordinarily not radio-opaque, and the author has removed coal from the vitreous body after recovery from the initial injury, a linear extraction of the cataract and later a clear pupil, so that the coal could be seen within the vitreous chamber. In these cases of mine explosions, the surgery should be done under general anesthesia. At that time, the multiple implanted bits of coal and of powder are to be removed from the skin of the lids and about the face with a stiff scrubbing brush and with forceps. There is no reason whatsoever why these should be permitted to remain. The primary surgery of the soft tissue destruction involves the removal of all tissue which is hopelessly damaged after that primary suturing, and later the correction of the cicatricial defects which are certain to develop.

SURGERY OF SYMPATHETIC OPHTHALMIA

The surgical treatment of sympathetic ophthalmia is properly discussed at this point.

It is time to change the current opinion that all injuries of the iris and the ciliary body may develop this condition. The clinical course of these injuries, sound surgical procedures, (as iridencleisis, cyclodialysis, and iris

[1] Matthews, Major J. L., Ophthalmic Injuries of War, War Medicine, vol. 4, Sept., 1943.

prolapse) and the course of sympathetic ophthalmia itself, when once established, seem to suggest that another factor must be present; and *chronic or long-standing irritation* may be this precipitating factor. The basic etiological essential tissue sensitivity or bacterial invasion must have, it seems, this additional cause in symbioses. The importance of this conjecture lies in the rational handling of such injuries. The removal of a limbal staphyloma involving the iris and the ciliary body by clean surgical methods should be uneventful, and it usually is that; the pre-equitorial subconjunctival rupture of a globe, from direct trauma, may terminate in sympathetic ophthalmia, and this frequently happens if enucleation is too long delayed.

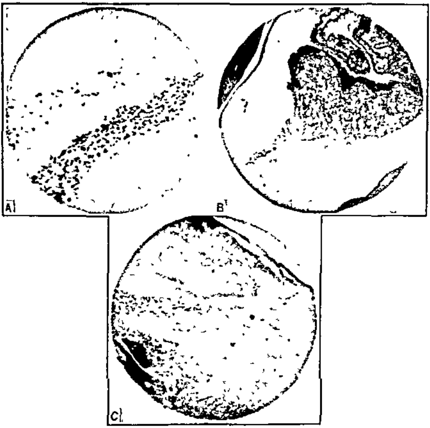


Fig. 504.—Slide of sympathetic ophthalmia Camp (*A*), round cells obliquing through the sclera following the course of a vortex vein. (*B*), from the same eye, showing the same round cell infiltration at the iris angle; Samuels (*C*), sympathetic ophthalmia tissue (round cells) lying extra-ocularly at the limbus, see the line of operation wound

Sympathetic ophthalmia has been seen to follow after illy-advised surgery in and for iritic glaucoma. This is probably the outstanding example. Irvine[1] feels that sympathetic ophthalmia cannot develop without perforation of the globe. It is quite possible that cases reported as such, because of their rarity, were really instances with a perforation, but that this may have been overlooked. Anderson's case[2] reported as such

[1] Arch Ophth., vol. 24, No 1, July, 1940.
[2] Acta Ophth., 16, 119, 1938.

without perforation showed later upon serial sectioning a small needle-sized puncture 10 mm. behind the limbus. As Irvine said:

> Once sympathetic uveitis has developed, enucleation of the exciting eye has no effect on the course of the disease, and this eye should be retained, if potentially useful, as it may eventually be the better eye. From the available data there is no indication that the exciting eye acts as a focus of infection "spilling over" into the sympathetic eye.
>
> Considering the frequency of occurrence of sympathetic ophthalmia, 1 per cent of all perforating injuries, attempts to save severely damaged eyes, especially if the lens is injured, are not justified if the fellow eye is normal. A distinct possibility of sympathetic uveitis must be considered when operation is contemplated on eyes nearly blind from any cause, as for instance, hemorrhagic glaucoma.

Histopathologically, this condition is a generalized infiltration of characteristic tissue cells which appear in all the pigmented coats of the eye, pass through the sclera with the emissary veins to lie in the extra-ocular connective tissues, and to follow along external to the vaginal sheath of the optic nerve. Surgery even upon the cornea may result in a further spread of these cells in the path of the keratome or the corneal knife—no wonder Samuels stated there is nothing which can be done in these conditions except an enucleation, and because of the extra-ocular migration of these tissue cells even this may not prevent sympathizing irritation in the opposite eye. The migration of these cells shows conclusively why one dare not do an eyeball evisceration in such instances—only a simple enucleation—and that with the longest possible stump to the optic nerve. Figure 504, *A*, illustrates the migration of these epithelioid cells, and *B* and *C* illustrate a section showing this infiltration along the course of an operative wound in an attempted iridectomy.

VISIBILITY AND LOCALIZATION OF FOREIGN BODIES

Spackman,[1] in his discussion of the localization of intra-orbital foreign bodies said:

> It is important for the ophthalmologist to familiarize himself with the methods of the roentgenologist, but it is equally advantageous for the roentgenologist to be acquainted with the problems as they present themselves to the operating ophthalmologist.

If a foreign body is responsive to the magnet, the operator will usually try to extract it through the wound made by its entrance. If the foreign body is in the vitreous, it is of great importance in many instances to make a check-up localization to determine how far it has been displaced, if the operator has not succeeded in removing it. If it cannot be drawn through the ciliary body, or if it adheres to the posterior capsule of an undamaged lens, it is often better to do a sclerotomy rather than continue to use magnetic traction in the original direction. If it is embedded in, or becomes firmly fixed to, the iris, it is often better to do an iridectomy. If the foreign body is large and is in the vitreous, especially in a case in which the lens is clear or the condition has been of long standing, with organization of material about the particle, it may often be extracted through a posterior sclerotomy. If it is in the lens, non-interference is sometimes the best policy until cataract develops. If the particle seems to be buried in the

[1] Arch. Ophth., vol. 18, No. 2, August, 1937.

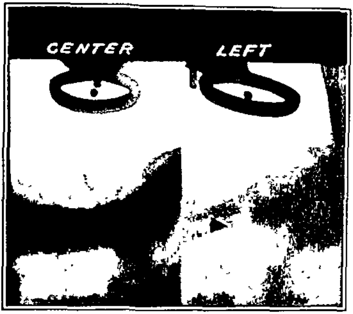


FIG. 505.—Roentgen-ray film used for plotting an intra-ocular foreign body.

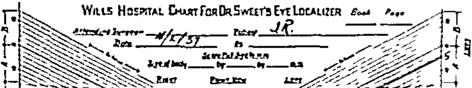


FIG. 506.—Chart used for plotting an intra-ocular foreign body.

sclera and the eye is quiet, many operators do not disturb it. Others give a single trial with the magnet and send the patient back for relocalization of the foreign body. If there is no movement, they go no further. If there is a double perforation and the eye is quiet, the foreign body is usually not disturbed. If the body is non-magnetic, it may sometimes be removed by searching blindly and sometimes by biplane fluoroscopic control. If it is not removed, it is a potential source of danger not only to the injured eye but also to the good eye, and if there is any doubt, enucleation should be seriously considered. Spackman estimates that in at least 10 per cent of routine cases, this question of double perforation has arisen. In 9 of the 10 cases, the question can be settled by the previously described procedures, but there still remain a few cases in which the condition is puzzling in spite of all attempts to obtain complete evidence. Figures 505 and 506 are the chart and films of a foreign body within the eye, to illustrate a definite case, while in Figure 507 are the films showing, by air, the posterior position of a double perforation

FIG 507.—Films illustrating double perforation of the globe. Foreign body lies posterior to the line of air in Tenon's capsule. *B* is the angled exposure. (Spackman.)

The roentgen-ray diagnosis of double perforation of the eyeball is a condition which can be readily diagnosed by the utilization of Spackman's air injection into Tenon's capsule.[1] Spackman's air injection technique follows: After thoroughly anesthetizing the eye, the patient is instructed to turn it downward and inward, a point about midway between the superior oblique and external rectus is located, and the conjunctiva grasped, using sterile precaution. A curved cannula is then inserted below the conjunctiva and the needle carried between the conjunctiva and Tenon's capsule for a few millimeters before puncturing the capsule. If a straight cannula is used, the air will leak back below the conjunctiva and into the retrobulbar tissue. An attempt is made to inject 8 cc. to 15 cc. of air.

[1] Am. Jour. Ophth., vol. 15, No. 11, November, 1932

When the eye is proptosed, due to air posterior to the globe, and increased resistance is felt on the piston of the syringe, the injection is discontinued. The proptosis must be apparent, and this is the best guide as to the correctness of the procedure. If the conjunctiva bulges forward, the needle is not within the space of Tenon, or there is too much leakage, and the test is of no value. The radiographs are made at several angles, as it is important to separate the shadow of the foreign body from that of the space of Tenon. The layer of air below Tenon's capsule forms a band which may be plainly visualized in contrast to the denser bony tissue of the orbit, and by making pictures from various angles the relation of the particle to the capsule may be accurately demonstrated. The entire procedure causes little or no pain; patients merely complain of a sense of pressure on completing the air injection, and are perfectly comfortable during the examination. In four or five days the air has disappeared without inducing untoward symptoms or complications (Fig. 507). The arrow indicates the foreign body. By angling, 30 degrees from the face, the foreign body is visualized posterior to this line of injected air. (In *A*, the foreign body would appear to be within the capsule of Tenon.)

This simple procedure as an aid in the diagnosis of a double perforation is positive in its results, and the simplicity of the procedure, with its freedom from objectionable features, makes it a most valuable means for differential diagnosis. Once the diagnosis has been made of a double perforation with the positioning of the foreign body posterior to the globe, then the surgeon can proceed accordingly. It is rather likely that copper, lead, and brass should always be removed if it is at all possible to extract the foreign body. Large particles of steel and of iron can be removed through an external orbitotomy, or even through a Kroenlein or an orbital wall resection. The biplane fluoroscope, further, is available for such cases

EXTRA-OCULAR FOREIGN BODIES

Retrobulbar foreign bodies are occasionally seen of such a size and lodged in such a position that surgical removal is quite out of the question It is either unnecessary to remove them, because their presence is not affecting the individual seriously, or the surgery necessary for the removal would need to be so extensive that it might endanger the patient's life Figure 508 is the roentgenogram of a so-called "punkin-ball" lodged in the medial wall of the left orbit, firmly encapsulated, without exophthalmos, without an accompanying ethmoiditis, or the limitation of breathing space, and completely covered by the ethmoidal capsule and the nasal mucosa. Even though this patient's left eye is sightless from a severed optic nerve, and an almost completely degenerated retina, it is satisfactory from a cosmetic standpoint. Removal of this foreign body would also need an enucleation.

MAGNETIC AND NON-MAGNETIC BODIES AND THEIR LOCALIZATION AND REMOVAL

After the localization of a foreign body, extraction is to be done with the least possible delay. Non-magnetic bodies must be removed through a posterior sclerotomy incision with special grasping forceps, as suggested by Cross, either using the direct observation of an ophthalmoscope, if the

state of the cornea, lens, and vitreous will permit this; and if not, the use of the biplane fluoroscope. In cases wherein the lens has been damaged, the case is not complete—regardless of the compensation laws which may be in force—until a linear extraction has given the patient maximum visual acuity return possible. Non-magnetic foreign bodies in the anterior chamber may be removed through an anterior keratome incision, and if these are incarcerated in the iris, an iridectomy may be most advisable unless the foreign body can be easily released without extensive manipulations.

Fig. 508.—Foreign body, "punkin-ball" firmly embedded in medial wall of left orbit.

Magnetic foreign bodies should be removed with a magnet as early in the course of the case as is possible. Later, cicatricial encapsulation may make their removal impossible. The posterior route, *i. e.*, through a posterior sclerotomy, is to be done only when absolutely necessary. In many of these cases, the steel can be dislodged from its bed on or in the retina and choroid, drawn into the suspensory ligament and through this into the posterior and then the anterior chamber of the eye, for subsequent extraction through an incision into the anterior chamber. The chance of cataract developing thereby is considerably less than that of retinal separation, for this appears in a very high incidence after a posterior route removal. The practice of introducing magnet points, and magnetized instruments into the vitreous is to be strongly condemned.

In all instances, whenever a posterior sclerotomy has been necessary, as soon as the foreign body has been removed, the scleral hole should be rimmed about with a barrage of Walker's micro-cautery needles, just as if an ordinary retinal separation hole was under treatment.

THE REMOVAL OF METALLIC FOREIGN BODIES FROM THE EYEBALL AND FROM THE ORBIT

The satisfactory disposal of cases of metallic foreign bodies in the globe and/or in the orbit presents two definite problems. The first of these is the diagnosis of the presence of a foreign body, a determination of its probable structure or alloy mixture and its accurate localization, the second, the surgical procedure to be used which is best for the removal of the foreign body under consideration. In considering extra-ocular foreign bodies, roentgen-ray plates are the ophthalmologist's single greatest diagnostic aid. Magnetic probes and other similar localizers will be used more and more in

FIG 509.—Side view film of multiple foreign bodies, bird shot

the near future, but only under circumstances of great stress and with time and equipment limitations. A third might be of importance at rare times, though this will not always be under one's control, *i. e.*, when is it wiser not to attempt the removal of a certain foreign body under treatment? The first two of these three are of greatest concern.

A rather logical controversy exists between ophthalmologists and roentgenologists as to the relative value of stereoscopic roentgen-ray films and films taken in a single plane—horizontal or vertical as the demand may be—but all exposures at a different angle. Some roentgenologists are quite *frank in stating that stereoscopic plates are inferior in their diagnostic*

value while others consider the reverse of this the fact. Actually, both means are important, though not always comparably so in a single case. Furthermore, the ophthalmologist should be more capable of deciding which of the two is to be used in any given case under consideration.

Figure 509 presents the side view in a case wherein lateral views taken at right angles to each other in horizontal and in vertical planes were of greatest value. The task of deciding which of these foreign bodies lie inside and which outside the orbit and if any are inside the globe is almost similar in extent of computations necessary to that needed in studying an astronomical photographic plate. The flat films taken at the varying angles in the two plates, however, showed rotation movements of the

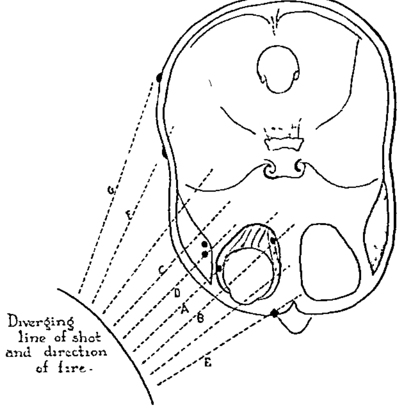


FIG. 510.—Probable position of foreign bodies by lateral and front view flat plates.

foreign bodies in relationship to each other and to the various fixed anatomical landmarks. It was thus possible to decide that of the four bodies in the region of the orbit (Fig. 510), *A* lay intra-orbital immediately behind the rim of the orbit, *B* within the orbit at the medial angle and the roof of the orbit, and *C* and *D* in close relationship to each other below the zygoma and within the temporal fossa. The deformation of the various shot (*E* and *F* as compared with *G*, *C*, and *D*) show well the lines of fire resulting in the deformity and fragmentation of the first two (Fig. 511). This has not occurred in the last three.

Apparently *G* struck the bones of the skull at a very tangential angle, *E* became fragmented against the solid bones of the frontal plate and the

F's were deformed because of their almost perpendicular incidence. *A*, *B*, *C* and *D* show but little change in shape because of their entry into the softer tissues of the orbit or the thick temporal muscle which cushioned the blow or force of impact. It is quite evident that in this case stereoscopic films would have been of much less value for orbital localization.

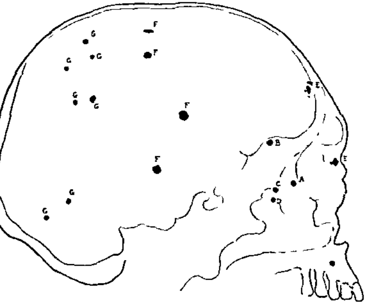


FIG. 511.—Further study of films (Fig. 509).

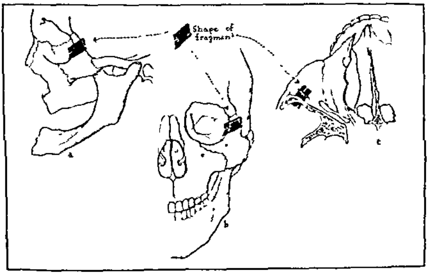


FIG. 512.—Localization from stereoscopic plates.

Figure 512 illustrates a case, however, in which antero-posterior stereoscopic views were of the greatest assistance. The foreign body lies, very probably, partly in and partly out of the orbit. Removal might be done through the temporal fossa or from an orbital approach, or a transcranial approach might even be considered (similar to a Naffziger orbital decompression); this would be considered more seriously perhaps in cases in

which the foreign body lies more superior and posterior. The patient was operated on successfully through the external route by a Shugrue bone resection, on the basis of these stereoscopic roentgenograms. A Kronlein resection, necessary otherwise, would have meant more extensive surgery with no better and perhaps even poorer results. The position of the foreign body would have limited the external bone flap, with danger to an eye already damaged by the original injury; also the degree of scar tissue in the orbit would have made that procedure rather more formidable.

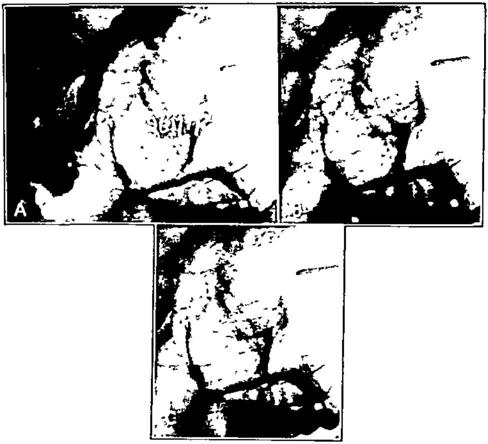


Fig. 513.—Study of foreign body for localization by parallax. *A*, Front view, see marker; *B*, upper rotation 45 degrees, *C* downward rotation, 45 degrees. (Spaeth, courtesy of Jour Am Med Assn.)

A further utilization of angle plates, this time in the vertical position, is necessary for the study of parallax. Figure 513 illustrates such an instance: A mine explosion victim had one remaining foreign body still retained; its position was uncertain. Here *A* shows the position of the foreign body, the marker being in exact contact with the apex of the cornea and 26 mm. from the foreign body, *B* is the same with the patient looking up 45 degrees, and *C* with the patient looking down 45 degrees. Charting these movements in relation to a 24 mm. eye, one can see that while there has been movement of the foreign body it is insufficient to indicate that the particle is in the eye or even in the sclera but that it must be extra-ocular and that the movement demonstrated must be due to muscular action. This conclusion should be sufficient.

while the hand magnet has its only indication in cases in which the magnet tip can be applied directly or approximated to the foreign body at an interval no greater than 2 mm. This is a clinical proof of Lancaster's criteria for good magnets: "Unless a giant magnet will pull a tiny steel ball with a force of over fifty times its weight, at a distance of 20 mm., and unless a hand magnet will pull a tiny steel ball in contact with its tip with a force over five thousand times its weight, they are not good magnets."

General rules can be laid down as to the selection of an anterior route extraction versus a transcleral extraction. The smaller the particle the more is the former indicated; the larger, the more is the latter indicated. An intact lens should be left so; hence a damaged lens tends to demand an anterior route extraction and permit it for larger fragments. Foreign bodies that have entered through the posterior segment of the sclera or which lie in the posterior portion of the globe should be extracted from the eye by the anterior route, all other factors permitting. If the point of entrance is well behind the ciliary zone and anterior to the equator, that extraction may be done through the point of entrance. The giant magnet can bring the foreign body toward this point of entrance for the easy hand magnet removal.

When the particle lies generally in the region of the equator on or in the retina and a posterior route of removal is deemed wise, the sclerotomy for the extraction is to be done on the sclera at that spot closest to the position of the particle, and the hand magnet should be used for the extraction. Sclerotomy incisions and points of entrance should be rimmed with diathermy needles to guard against a later retinal separation. Foreign bodies suspended in the vitreous usually need the giant magnet for extraction. Early surgery is perhaps the greatest factor in these cases unless the foreign body lies wholly within the lens. When only a hand magnet is available, accurate localization is absolutely necessary. With the giant magnet this is less important. A permanent magnet has but little value except with foreign bodies in the anterior chamber, and even here their magnetic attraction force is so slight as to be of doubtful value.

Foreign bodies which are incarcerated in the ciliary body must be removed through the anterior route from the angle. Foreign bodies, however, adherent to the retina behind the ciliary body in the pars ciliaris of the retina should be removed through the posterior route by means of a posterior sclerotomy (radial incision of the sclera with stay sutures in the sclera as outlined for the sclerotomy of a cyclodialysis) behind the ora serrata. The magnet can move the foreign body away from the ciliary processes, prevent entanglement in these thereby, and then deliver the foreign body through the sclerotomy incision.

Foreign bodies in the anterior chamber angle can be well visualized with a contact glass. A knife needle may be necessary and sufficient to dislodge them from their position there and thus permit a satisfactory extraction by means of the hand magnet through a keratome incision at the limbus nearby.

Foreign bodies which are known to be under the retina or incarcerated in the retina must be removed by the posterior route. Transvitreous delivery will almost certainly cause a sudden and abrupt separation of the retina by immediate extraction traction and tearing of the retina. This

applies also to those foreign bodies which can be seen with the ophthalmoscope as buried in part in the retina. Retinal separation is an ever present danger in posterior route extractions even under the best of circumstances. Means to prevent this have been discussed, but deliberate damage to the retina by unwise anterior route extractions is not necessary

The anterior route extraction has as its purpose the prevention of further operative damage. Hence, in its use one must prevent incarceration of the foreign body in the iris or the ciliary body and damage to an intact lens.

When metallic foreign bodies are removed from the anterior chamber it is important that the corneal incision be perpendicular to the cornea and not obliquely placed at the angle, for this latter incision will form a shelf, making difficult the removal of a flat or scale-shaped particle. After a keratome incision and with magnetic pull, when the iris prolapses because of an incarcerated foreign body, a single meridional forceps-scissors iridotomy may permit the removal of the particle through the iris and the replacement of the iris. When a giant magnet is available, it is a good working rule to use the giant magnet and to attempt an anterior route extraction whenever any doubt exists as to which of the two procedures is the better for a given case. In general, the conditions which demand a posterior route extraction are few but when they are present they also are rather inflexible.

Usually it is useless to work with any type of magnet head except the blunt tip with the broadest magnet field; similarly, the introduction of forceps, probes, scissors and similar instruments into the eye, these in contact with the magnet core, is of little value as far as the magnetic pull is concerned. This also may be the cause for considerable damage to the retina and the choroid. One must remember that the hand magnet alone is a contact instrument and that the giant magnet alone permits varied manipulations at different angles for attraction for dislodging an incarcerated particle, for guiding a metallic particle around the posterior surface of the lens and for diagnostic purposes. Further, it is wise to remember that all foreign bodies, when magnetically attracted, move with their long axis parallel to the pull of the magnet—never at any great angle from this—and even this deviation from parallelism is only mechanical and due to the friction of structures touching the foreign bodies during the extraction.

Extra-ocular foreign bodies are similar in their individual demands, i. e., the giant magnet versus the hand type, when a magnetic extraction is considered from soft tissues, as the lids, or from the depths of the orbit.

Technique.—The path of entrance of a foreign body, its size, and its position are not the only points to be considered when discussing the foreign body extraction by an anterior or a posterior route. It would be quite absurd to jeopardize the entire eye by removing a huge intra-ocular foreign body, as a half-inch length section of steel wire cable, through the anterior route. On the other hand, a small foreign body can be carried through the zonula around the equator of the lens, and into the anterior chamber from the posterior chamber without danger to the lens capsule, except under most unusual circumstances.

The hand magnet is first applied to the sclera over the point where the localization has placed the foreign body. It is then slowly moved, being held in close approximation to the sclera until the magnet p passed the limbus and over the anterior chamber angle. One

see bulging of the iris, as a result of the foreign body in the angle of the posterior chamber. The magnet is then lifted from the sclera and reapplied against the cornea away from the foreign body, that is, the magnet point is toward the pupillary aperture. An attempt is now being made to move the foreign body into the pupillary aperture, and at the same time to prevent its incarceration in the meshes of the iris stroma on the posterior surface of the iris. If this cannot be achieved very promptly, a keratome incision should be made at that point without delay, the iris incised with a knife-needle, and the foreign body withdrawn through this opening in the iris. At times it may be necessary to do a complete iridectomy.

The removal of a magnetic foreign body through the posterior route is a simpler procedure. There is no doubt of this. It is, however, fraught with danger because of the possibility of the subsequent retinal separation. In these instances, the conjunctiva is opened, and the sclera incised meridianally at a point on the sclera as close as is possible to the roentgen-ray localization found. The blunt, cone-shaped magnet tip is placed against the sclerotomy and the current closed. Foreign bodies of unusual shapes should be removed, naturally, smallest diameter presenting.

Non-magnetic Foreign Bodies.—There are three procedures available for this.

Endoscope.—The principle of this is a telescopic tube, self-illuminated, with various types of grasping forceps—a principle and procedure carried out in the bronchoscope, cystoscope, and other similar instruments. The endoscope of Thorpe is the model of outstanding efficiency. The instrument is passed through an equatorial scleral incision at a point opposite to the site of foreign body localization. The magnified field of the endoscope permits a view of the entire intra-ocular fundus. The foreign body is to be grasped with the double-acting forceps—the forceps selected depends upon the size and shape of the foreign body, as a ring forceps for a BB shot, or a flat-jawed forceps for a scale of copper. The forceps and endoscope are withdrawn simultaneously. Naturally endoscopic examination and foreign body removal presupposes a vitreous without hæmorrhages, and reasonably clear from massive floating opacities.

Some practical points relative to this instrument and learned by experience are worth repeating. The endoscope should be introduced slowly and deliberately, and the movements of the grasping forceps and the telescope end should be no more than is necessary. One should depend on careful preoperative planning to minimize damage to the vitreous. The forceps should be advanced very slowly and gently to prevent damage to the delicate retina. An assistant must fix the eye adequately and watch, at the same time, to prevent too deep a penetration of the endoscope into the vitreous chamber. Vitreous should not prolapse while the instrument is in use unless the wound penetration is either too large or must be made larger because of the size or shape of the foreign particle. The structure of vitreous bands from infiltration and exudates may make difficult the grasping of a foreign body which is suspended free and not supported by incarceration in some structure.

The foreign body is withdrawn with the endoscope, the eye of the operator never wavering from the eyepiece until the instrument is free from the eye. The final grasp, once obtained, on the foreign body should be firm and adequate even if it is necessary to turn the particle a bit to obtain

this. In the case of odd-shaped particles, such as scales, chips, or irregular fragments, withdrawing through the scleral incision is successful only when the foreign body is grasped properly, *i. e.*, the long axis parallel to the pull of the forceps. The sclerotomy incision should be rimmed with diathermy needles after withdrawal of the forceps as was mentioned for the transcleral posterior route magnet extraction. The vortex veins must be spared regardless of the position of the foreign body.

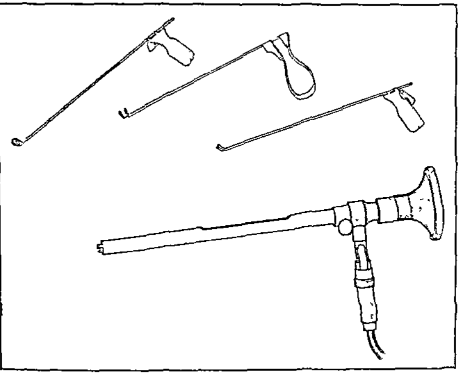


FIG. 514.—Drawing of Thorpe's endoscope (somewhat reduced in size) and various grasping forceps.

Experience with the instrument has been sufficient to agree wholly with Thorpe's claims relative to the value of the instrument. See Figure 514 for sketches of the instrument and of the forceps; one, the lowest, designed for removing a splinter of glass; the middle, for grasping a BB shot, and the remaining used for removing a thorn after intra-ocular penetration.

Before the endoscope is first used by an operator, he should drill himself into efficiency with the instrument by selecting and picking out tiny foreign bodies of various sizes and shapes from the inside of a closed pill-box—simulating thereby, the closed fundus of an eyeball.

Radio-opaque Landmarks.—Non-magnetic foreign bodies which have become lodged and firmly seated in the retina and the choroid can be rather readily removed by a hinged trap-door sclerotomy. Three rings of silver wire are sutured to the globe, one at the limbus, a second at the ora, and a third at the equator. See Figure 515, which is the representation of a case of intra-ocular copper lying in the eye upon the sclera (diagrammatic sketch, Figure 516) successfully removed through the use of scleral landmarks and by means of a trap-door flap in the sclera. A roentgen-ray

plate is then taken with these in position, anterior-posteriorly, and a second laterally.

Many different types have been presented from time to time. Excluding

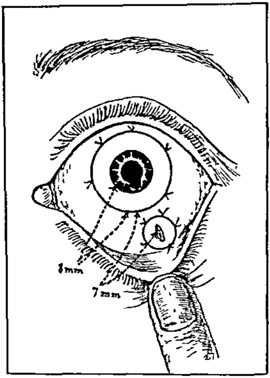


FIG. 515 —Localization by rings sutured to the sclera, subsequent radiological study and removal of foreign body.

iodized poppy-seed oil, all of them are in principle an open wire cage which fits over the cornea onto the scleral shoulder. The great difficulty with most is their inaccurate fit, in that scleral and corneal curves vary suffi-

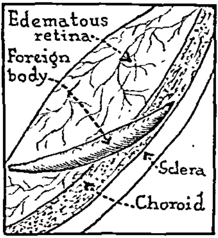


FIG. 516 —Schematic sketch to show position of foreign body in Figure 515.

ciently within the normal limits to make errors of 2 and even 3 mm. common. Such errors in localization are not permissible for the satisfactory

removal of a foreign body. Their greatest value is not to augment localization. This can be done with full satisfaction by the Sweet method, certainly with intra-ocular particles and within certain fair limits also with regard to extra-ocular particles. Instead they (these radio-opaque landmarks) furnish fixed external surface markings from which fairly exact

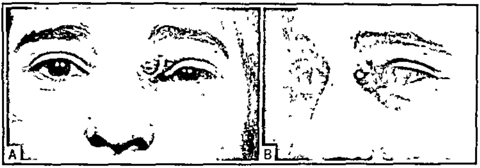


Fig. 517.—Foreign body cyst and fistula.

Fig. 518.—Lateral view x-ray of foreign body.

measurements can be made to permit the removal of a non-magnetic foreign body. With these landmarks as fixed, measurable and firm points, a trap-door sclerotomy is made over the site of the foreign body as it appears in those roentgen-ray plates, after a conjunctival section, and this lifted with its hinge posterior, and the foreign body removed through the trap-door with a clean section of the retina and the choroid. The scler-

otomy is then closed with 6-0 catgut sutures, and this entire region rimmed with small diathermy needles to prevent a subsequent retinal separation.

Iodized poppy-seed oil itself can be floated behind a Koeppe contact lens, giving a perfect radio-opaque landmark for accurate localization of a

FIG 519 —Iodized poppy seed oil injection to show position of foreign body.

foreign body lying in or at the anterior chamber, at the root of the iris, and at the ciliary body. It may be the means of deciding the exact position of minute metallic particles. Figure 517, an instance of an extra-ocular body, shows a further use of this oil. The patient had a foreign body cyst

FIG 520.—Front view with scleral markers in position showing iodized poppy seed oil in foreign body cyst for composite localization and identification of landmarks

with a draining fistula. Figure 518 shows the roentgen-ray appearance of the foreign body, and Figure 519 shows the appearance of the cyst after injection with iodized oil. Figure 520 shows, by measurement, the extent of the canthal angle, the cul-de-sac and the position of the cornea. The

removal of a foreign body as such is facilitated by these various localization methods.

Biplane Fluoroscopy.—The removal of non-magnetic foreign bodies from the eye is a matter of biplane fluoroscopy with extraction through a scleral incision. Cross,[1] in 1927, was apparently the first to report this

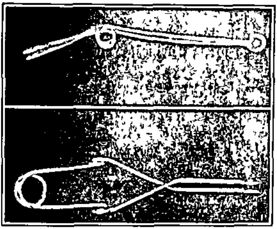


FIG. 521.—Cross foreign body forceps (Borley and Leef.)

Accurate localization is first necessary, and with these films, working with his ring, cross-action-forceps, under the fluoroscope, guided by the radiologist, removal should be uneventful. Borley and Leef[2] recently reviewed this work and presented their experiences in such an instance. Figure 521 illustrates the Cross forceps, and Figure 522 is a film of these forceps with

FIG. 522.—Roentgenogram showing a foreign body within the grasp of the ring forceps (Borley and Leef.)

a lead shot within the grasp of the rings. The incision of the sclera, the introduction of the forceps, and the removal of the shot can all be carried out in the fluoroscopic room, while the diathermy coagulation treatment, to the area of the sclera and the choroid through which the shot is removed, is completed immediately therafter in the operation room. (This precau-

[1] Trans. Am. Ophth., Soc. 1927.
[2] Am. Jour. Opth., vol 20 No 12, December, 1937.

tion has been previously discussed.) These cases must be operated as soon as is possible for the irritation which develops from the retention of the foreign body (as lead shot) for any length of time results, as Borley and Leef found, in vitreous adhesions and in a plastic iridocyclitis.

The biplane fluoroscope has two general applications—the first quite proper and of undoubted value, and the second occasionally necessary, even compulsory, but always fraught with danger to the integrity of the eye.

The first of these is the necessary removal of retrobulbar deeply embedded, radio-opaque foreign bodies. The technique has no equal; in fact there is no alternative. The operation can be performed with careful dissection and with deliberation to a certain extent, interrupted and the patient moved into the fluoroscopic room and thereafter returned to the operating room for the resuturing of the detached muscles, for the closure of the skin and conjunctival incisions, and for the dressing. The exact removal of the particle demands accurate localization, a bit of gentleness in the use of grasping forceps and that detailed knowledge of the anatomy of the orbit which all operators should have.

The second indication is connected with the removal of an intra-ocular, radio-opaque, non-magnetic foreign body not attached to nor in close proximity to the retina and with vitreous clarity disturbed by hæmorrhages or exudate. This prevents the use of the endoscope; and one dare not attempt the removal of such a foreign body by means of a sclerotomy flap unless the particle can be grasped with exactness through the sclerotomy opening. In such cases a biplane fluoroscope must be used, knowing, however, that grave disorganization of the retina, the choroid, the vitreous or the lens may result. This need not follow necessarily, but it does sufficiently often to make one unwilling to use the procedure for intra-ocular particles unless absolutely required. The various grasping forceps used for the endoscope are as valuable now as when used otherwise (Fig. 514). Forceps that depend on their opening and closure by the conventional two-blade spring connection construction are limited in efficiency. The size of the sclerotomy controls the degree of forceps opening possible as well as does the ease of rotation of the instrument within the opening depend upon the caliber of the grasping instrument.

CHAPTER XXVII

ROENTGEN-RAY AND RADIUM THERAPY—MALIGNANCY IN AND ABOUT THE ORBIT AND THE GLOBE—PLASTIC REPAIR OF TUMOR SITES

RADIUM AND ROENTGEN-RAY THERAPY—CONSIDERATION OF MALIGNANCY IN AND ABOUT THE ORBIT AND THE GLOBE

This has already been covered in various subsections throughout the text. Recapitulation of important and pertinent factors is necessary now.

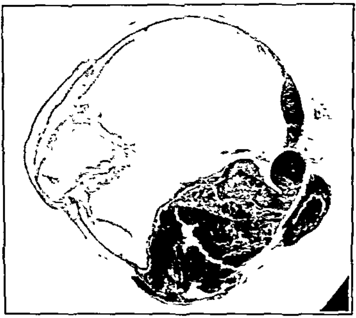
(See Sections on Exophthalmos; that of Space Taking Lesions, Section of Plastic Correction of Lid Defects Following Malignancy; Section on Iris Surgery as to Malignancy; Section on Differential Diagnosis of Retinal Separation from Malignancy.) Intra-ocular malignancy which is extended by continuity of tissue through the scleral shell into the orbit cannot be always positively diagnosed. Long-standing blindness, however, with absolute glaucoma and with a rapidly developing exophthalmos should make one suspicious of such a situation. Figure 523, *A*, is a microphotograph of the eyeball and retrobulbar malignancy as a result of such a perforation of the globe. Some of these instances are unavoidable in that the patient has failed to report to the ophthalmologist early enough for a diagnosis and proper treatment. The condition when present as just described is very serious. Intracranial metastases are a common thing. In addition, other more distant metastases are almost as frequent The finding at operation of a situation as illustrated in Figure 525 is practically a hopeless situation. Figure 525 is the more common picture of primary melanoma (pigmented sarcoma) of the choroid, diagnosed prior to surgery and confirmed by the enucleation. In Figure 526 relief was also sought too late by the patient. Liver metastases were already established, apparently, at the time of the enucleation. The necessity for early diagnosis is imperative.

Contact roentgen therapy of superficial malignant lesions about the eye has been stressed rather recently by Howes and Camiel.[1] In their technique, roentgen therapy is delivered through cones with tips which can fit into the canthi or into any position of the lid where the treatment is indicated. They use a target in distance of from 1.8 to 3.8 cm. and give approximately 10,000 r. in forty-eight to fifty seconds. This amount they feel is usually sufficient to eradicate a skin neoplasm. When the target skin distance is increased to 3.8 cm. divided doses are given of from 6000 to 8000 r. Inaccessible lesions such as those deep in a canthus may be reached without injury to surrounding overhanging structure. The cones used are small, shockproof, and protect other vital ocular structures.

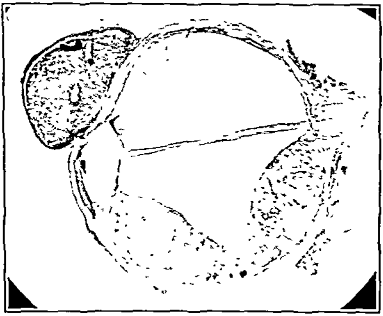
Retrobulbar neoplastic conditions have been covered in detail (Chapter II). Emphasis here is as to the necessity for differentiating between a retrobulbar metastatic lesion and a retrobulbar primary lesion. In the first of these two, surgery, that is, a complete exenteration of the orbit, can be only an operation for ameliorating the symptoms of a painful pro-

[1] Arch Ophth, vol. 29, No. 2, February, 1943.

gressive exophthalmos. The patient is doomed by reason of the primary lesion. Such instances are seen in metastases of the orbit from an osteogenic sarcoma in the pelvis, an orbital metastasis from an undiagnosed



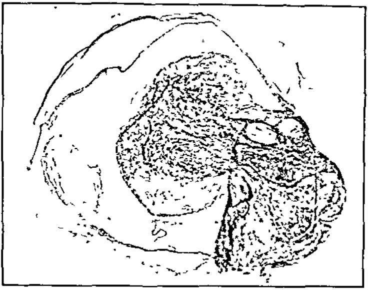
A



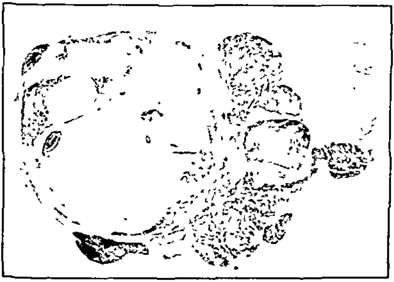
B

Fig. 523.—Intra-ocular malignancy which has passed through the sclera. *A*, through the posterior pole though still encapsulated within lamellæ of the scleral shell. *B*, extension through a trephine opening. Diagnosis of secondary glaucoma. The secondary glaucoma which was present was the result of the undiagnosed malignant melanoma. The trephining which, certainly, was an operative error, permitted the extension of the intra-ocular malignancy. (From the Pathology Collection, Wills Hospital, Philadelphia; courtesy of Dr. Perce De Long.)

hypernephroma, the orbital metastases of rapidly growing pigmented skin carcinomata, these all quoted as specific instances.



A



B

FIG. 521.—*A*, Extra-ocular extension of primary intra-ocular malignancy which has broken through the sclera and is no longer encapsulated. An apparently separate infiltrating nodule was directly responsible for the enormous exophthalmos present. *B*, intra-ocular malignancy, undiagnosed in life, secondary glaucoma, exophthalmos, orbital invasion, inoperable except for temporary amelioration of the pain from the absolute glaucoma and the exophthalmos. Exodus in such a situation almost certain, because of intra-cranial extension. (From The Pathology Collection, Wills Hospital, Philadelphia; courtesy of Dr. Perce De Long.)

The age of the patient is of importance in differentiating the diagnosis of these various situations. The gliomata, neuromata, and sarcomata of the early years of life are characteristic. Intra-ocular malignant melanomata

appear usually between the twentieth and the fiftieth years of life, as do also, the retrobulbar mixed cell sarcomata. Metastatic neoplasms occur most commonly after the fiftieth year of life.

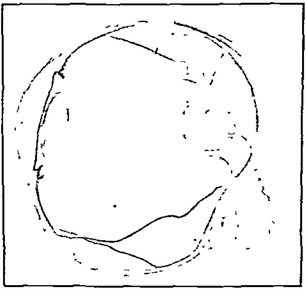


FIG 525.—The common picture of primary malignant melanoma of the choroid. Enucleation followed by radium therapy to the orbit. Death from liver metastases two years later. (From The Pathology Collection, Wills Hospital, Philadelphia; courtesy of Dr. Perce De Long.)

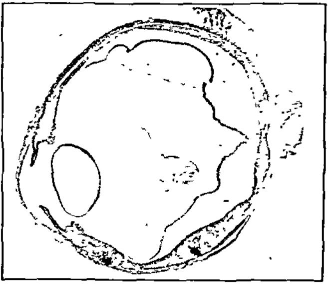


FIG. 526.—Melanoma of the choroid undiagnosed until liver metastases had occurred. Clinical diagnosis was idiopathic flat detachment. (From The Pathology Collection, Wills Hospital, Philadelphia; courtesy of Dr. Perce De Long.)

The differential diagnosis of epibulbar malignancies is a fairly simple procedure. The ease with which one can obtain a biopsy is naturally the greatest reason for this. Epibulbar gummata and non-malignant papillomata, while rare, are sufficiently common to make necessary an accurate diagnosis.

Malignancies of the skin about the lids and on the lid margins are naturally best treated when they are small. At that time, thorough treatment can be applied with the least cosmetic defects resulting. Recurrences are *always more difficult to handle, and the defects which result finally after* successful treatment are considerably more extensive. All lid marginal lesions are not malignant. Chronic long-standing recurrent chalazions not infrequently look like a basal cell carcinoma and are occasionally resistant to the usual forms of therapy. Actually, many of these do either develop into malignancies or were that from the onset. It is a simple matter to radiate such suspicious lesions thoroughly, and if then an early decrease in the lesion does not occur, resection and closure by means already discussed can be carried out with the highest margin of safety.

FIG. 527.—Malignant melanoma arising from a long-standing quiescent benign melanoma. Death through intracranial metastases twelve months later.

Relatively minor pigmented lesions of the conjunctiva need very careful treatment. *In a small number of instances rather wide surgical extirpation* of the conjunctival lesion may result in a satisfactory removal without recurrence. In general, however, these cases should have thorough radium treatment following the removal of microscopically confirmed pigmented malignancies. The possible intercurrent complications of a cataract from radium exposure is relatively minor when compared to the danger present

to the patient's life through late metastasis. Figure 527 is the illustration of such an instance. A minor but long-standing, quiescent, pigmented mole of the conjunctiva was activated into malignancy by a rather severe traumatism to the conjunctiva. Shortly after, the lesion began to grow.

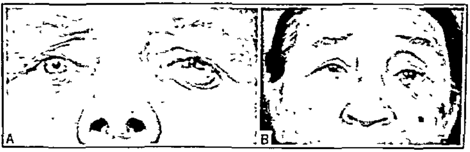


FIG. 528.—*A*, Squamous cell carcinoma. *B*, basal cell carcinoma. Conjunctiva also involved.

It was immediately resected from the globe. A recurrence appeared several months later, and an enucleation was done followed by a radium implant. Recurrence again appeared in the orbit and an evisceration was done of all orbital contents with further roentgen-ray therapy. The case terminated by metastasis to the mediastinum and death. It is possible that all of

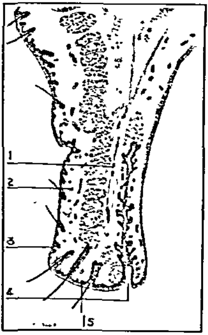


FIG. 529.—Schematic drawing after Thiel. *1*, Superficial and *2*, deep hemangiomata; *3*, basal and prickle cell carcinoma; *4*, adenocarcinoma; *5*, melanoma.

these might have occurred in spite of primary irradiation, had that been done. The incidence of recurrences following primary irradiation, after the initial surgery, is undeniably lower than the number of recurrences which appear without this primary therapy. Figure 528, *A*, is a similar

pigmented lesion of both surfaces of the lids, conjunctival as well as epithelial; hence of serious note from the standpoint of prognosis, which

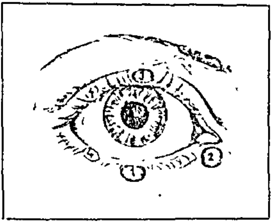


FIG. 530. Schematic drawing after Thiel. *1*, Basal cell carcinoma; *2*, prickle cell carcinoma; *3*, adenocarcinoma; *4*, melanoma.

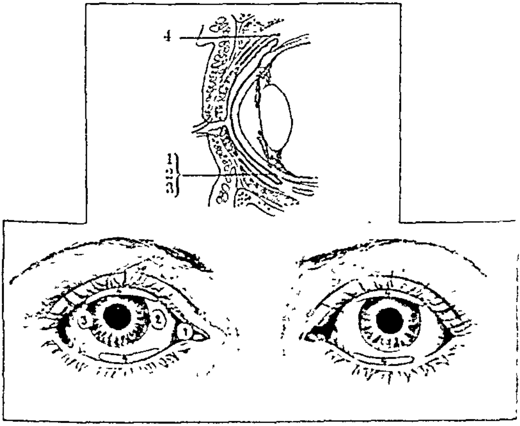


FIG. 531. Schematic drawing after Thiel. *1*, Papilloma; *2*, epithelioma; *3*, melanoma; *4*, lymphoma.

was removed surgically and then radiated. In spite of its extent (both surfaces of the lid), there has been no recurrence in an interval of five

years. Figure 528, *B*, is a rather different condition; it is a case wherein one of several different pigmented dermatoses became malignant, histological section of the lid lesion showing malignancy while a section of another on the lower cheek was not malignant.

The differential diagnosis of malignancies of the lids and the culs-de-sac, intra-ocular, and retrobulbar, can be assisted appreciably through the excellent review of this subject by Thiel.[1] The following schematic drawings and line sketches from roentgenograms, Figures 529 to 532 inclusive, are from his survey, "Diagnostik und Therapie der Geschwülste des Auges und seiner Umgebung." Figure 529, 1 and 2, indicate the most common sites for deep and superficial hemangiomata, 3, for basal cell and prickle cell carcinoma, and 4, for adenocarcinoma, and 5, melanoma. In Figure 530, 1 is the most common site for basal cell carcinoma, *i. e.*, 55.5 per cent; 2, for prickle cell carcinoma, *i. e.*, 27.3 per cent; 3, for adenocarcinoma, 11.8 per cent; and 4, for melanomata. In Figure 531, 1 is the most common site for papillomata, 2, for epitheliomata, 3, for melanomata, and 4, for lymphomata. In Figure 532 the malignant melanomata are respectively:

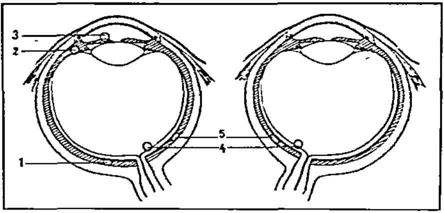


FIG 532.—Schematic drawing after Thiel, illustrating common sites for intra-ocular malignancy *1* Retinal, *2*, ciliary body; *3*, the iris, *4*, metastatic neoplasms; *5*, neuroblastoma.

1, retinal 85 per cent; 2, ciliary body 9 per cent, and 3, iris 6 per cent; 4, is the most common site for metastatic neoplasms to the uveal tract; and 5, the most common position for neuroblastomata. Figures 53 to 64 are line sketches of orbita to illustrate roentgen-ray shadows. Figure 53 is that of a tear gland malignancy, Figure 54 is one of a sarcoma of the roof of the orbit, Figure 55 of a carcinoma of the frontal sinus, Figure 56 is that of a carcinoma of the maxillary antrum, Figure 57 is one of a hemangioma of the orbit, the left orbit slightly the larger of the two showing calcified phleboliths. Figure 59 shows the sharply circumscribed shadow of a retrobulbar neurinoma with thickening of the shadow formed by the lesser wing of the sphenoid. Figure 59 is a further view of this case with hyperplasia, almost hyperostosis, of the lesser wing of the sphenoid and the narrowed optic foramen. Figure 60 shows the widened orbit of a retrobulbar glioma, with another view to show the overshadowed widened optic foramen. Figure 62 shows the shadows of a meningioma of the lesser wing of the sphenoid with marked thickening of both lesser and major wings of the sphenoid and with areas of calcification—together the

[1] Die Bösartigen Geschwülste des Auges und seiner Umgebung, Dr. Rudolf Thiel, Ferdinand Enke, Verlag Stuttgart, 1939 (Beihefte d. klin. Monatsbl f. Augenhlk., 6 Heft., 1939).

cause for a deformity of the superior orbital fissure. Figure 63 is a side view of this same case showing areas of calcification, rarefaction in the dorsum sellæ, and with further deformity in the anterior clinoids Figure 64 is the same case photographed through the base showing deformity and enlargement of the foramen rotundum and the foramen ovale.

The sketches are presented as a very probable aid in differential diagnosis for they are the findings of a rather extensive series of relevant malignancies.

Glioma Retinæ, from a pathological standpoint, is rather well subdivided into five classes. The review of McCrea's[1] is to be used and he is *quoted as follows:*

"1. Retinoblastoma.—Corresponding to the medullablastoma of the brain. These comprise the great majority of so-called glioma. Owing to the embryonic nature of the cells malignancy is high. They most often arise from the inner nuclear layer and next most often from ganglion cells and the nerve fiber layer.

"2. Neuro-epithelioma.—They are composed of primitive spongioblasts The external nuclear layer is the usual point of origin. In the pure form they may arise from the ciliary processes. These growths show rosette formation, the presence of which is evidence of partial differentiation into rods and cones. In consequence a somewhat lower malignancy is found

"3. Medullo-epithelioma.—These are very rare. They arise from the ciliary epithelium,—the place where the medullary epithelium of the primitive neural tube persists in almost undifferentiated form.

"4. Neurocytoma.—A few tumors have been described with their cells differentiated as neuroblasts or neurocytes.

"5. Astrocytoma.—These arise from the true glial tissue, and for it the term glioma ought to be properly reserved. It is common in the brain, but surprisingly rare in the eye, since astrocytes are plentiful in the eye The tumor appears in the second or third decades of life."

The first two groups mentioned are common, the last three are exceedingly rare. Their sensitivity to radiation therapy will be mentioned later, but in general of the first two the retinoblastomata are the more susceptible, and in the three latter and more rare forms, radiosensitivity is very low

A point as to radical surgical therapy in these cases is significant Of the 12 cases reviewed and reported by McCrea, there were 5 fatal cases death from extension occurring from four months to four years after the removal of the eye. "(McCrea) of the fatal cases the period occurring between the diagnosis and the removal of the eye being respectively, seven months, nine months, ten months, nine years and four months."

The diagnosis of lymphomatoid diseases of the eye and the adnexa can always be suspected, and properly so, in certain types of cases. This diagnosis cannot be confirmed, however, without histological examination. McGavic's analysis[2] is as follows, in percentage incidence (approximately):

	Per cent
Reticulum cell lymphosarcoma	35
Simple lymphoma or lymphocytic cell lymphosarcoma Exact histologic classification not agreed upon	30
Lymphocytic cell lymphosarcoma May develop leukemia	10
Giant follicular lymphosarcoma, localized Classification not agreed upon	10
Giant lymphosarcoma, follicular, generalized	5
Hodgkin's disease	5
Lymphosarcoma, unclassified	5
Simple lymphoma of the iris (Lymphocytic cell lymphosarcoma)	5

[1] McCrea W. B E , Brit. Jour. Ophth , vol. 2 13

[2] McGavic, John S , Arch. Ophth , vol 30, No 13

The sites of the tumors in this series were: 5 subconjunctival, 7 of the lacrimal gland, 5 of which were primary, 3 in the orbit, 2 of which were primary, 5 of the lids and the orbit, and 1 of the iris.

Therapy

Under ordinary circumstances, malignancy about the eye, *i. e.*, the soft tissues of the eye, the globe itself, and the orbit, should be treated by radium therapy. Occasions may arise wherein radium is not available. In such instances, naturally, roentgen-ray therapy will be necessary. The value of roentgen-ray therapy compares rather favorably with that of radium therapy, except that it cannot be as well localized and the tissue destruction therefore is likely to be more general. In instances of soft tissue neoplasms wherein the auricular and pre-auricular glands have become involved by metastases, roentgen-ray therapy is probably of greater value by reason of its dispersion than is radium therapy. The dosage in these instances is a matter for the roentgenologist, however; the ophthalmologist is seldom called upon, nor should he be asked, to decide the total dosage in such instances In roentgen-ray therapy, the term "erythema dose" is the quantum criterion for the amount of exposure. A one-quarter erythema dose would be the exposure from a 9 inch spark gap at 40 cm., 125 K V. P current (kilovolt potential); this exposure would be filtered through 1 mm. of aluminum. This amount of current for superficial malignancy could be used at weekly intervals for from six to eight applications

Malignancy of the bone is usually of rather serious import, though in some instances, surgery combined with radium will affect a recovery or, in less satisfactory cases, lengthen the life of the individual to a great extent. The recital of two such instances follows herewith. Figure 72, *A*, is an illustration of a thrice recurrent epithelioma at the outer angle; the third time it recurred within the soft tissues, it was resected in its entirety with electrical desiccation, and the rim of the bony orbit removed with biting forceps. Two years later, Figure 72, *B*, a canthoplasty, was done at the outer canthus, and the patient has continued since then without further recurrences. The second instance was a man, aged sixty years, with a recurrence in the orbit following an enucleation for an intra-ocular pigmented sarcoma. A second recurrence occurred in this case, involving the bone of the floor of the orbit to such a degree that after further surgery, the maxillary antrum and the orbit became a single cavity. A third recurrence developed on the lateral wall of the orbit. This recurrence was initiated by severe hæmorrhages from the posterior ethmoidal veins. A sequestrum was removed at that time, and further radium was used. The patient died two years later from a hæmorrhage which probably arose from the cavernous sinus as a result of progressive bone destruction from the malignant process. (See section on Surgery of the Orbit for further details in the surgery of the bony orbit as it applies to malignancy.)

Figures 34, *A*, *B*, and *C*, are sketches illustrating the surgery for the removal of the usual osteogenic sarcoma as well as bony cysts. (See Figs. 32 and 33.) This is the usual site for these conditions. The exposure is obtained by a crescentic incision of the skin incision of the periosteum at the lip of the orbit, and displacement of the peri-orbita with the contents

of the orbit medially. It permits necessary surgery even into the maxillary antrum, including the entire floor of the orbit, as well as the roof of the antrum.

For soft tissue epitheliomata and other neoplasms of the lids, radium is best used. The element, or the emanations of the element, are in an ampule of brass cartridge containing from 20 to 50 mg. of the element, depending upon the size of the lesion. This is filtered, ordinarily through brass, lead, and rubber of 1 mm. thickness each, the distance of its application being from actual contact to 3.5 cm.; the time of the contact being from one or two hours to twenty-four hours.

One milligram of radium (*emanation*) contained in a sealed tube is equivalent to 1 millicurie. The disintegration of this amount would occur in one hundred thirty-three hours. The minimum effective surface for treatment is a sphere 1 cm. in diameter lying about 1 mg. of radium placed at the center of the curvature of this sphere. In general, the distance between radium and skin should not be less than one-third of the distance between the skin and the lesion (Stallard).

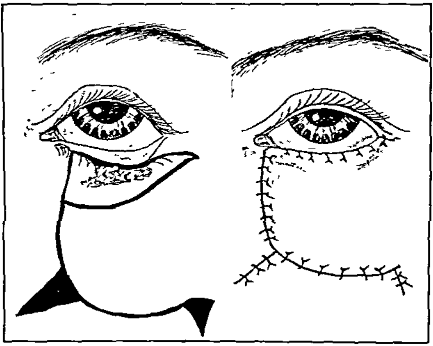
Radio activity depends upon alpha, beta, and gamma rays. The alpha particles are massive particles with a positive electric charge, very slow in velocity as compared with beta and gamma rays, and they are stopped by a sheet of paper. They play no rôle in radium therapy. Beta rays contain a negative electric charge which is easily deflected, but in a reverse way to alpha particles, and while they possess a higher penetrating power than the alpha particles, this as well as their velocity is considerably less than the gamma rays. They are a factor in causing superficial burns when using unscreened rays and can be divided, according to Stallard, into three types A, those stopped by a platinum filter of 0.2 mm.; B, those which can penetrate a 0.2 platinum filter but are unable to pass through an 0.2 mm. silver filter; and C, those capable of penetrating both of these filters. The gamma particles are the rays of use in radium therapy. They possess no electric charge and are not deflected by a magnetic field. Their penetrating power is great, their velocity is approximately 300,000 mm. per second, and they possess ionization and photographic qualities not possessed by either the alpha or the beta particles.

A milligram hour, in the vocabulary of the roentgenologist, is the amount of radium, or emanations, in milligrams multiplied by the number of hours it has been exposed. The exposure, therefore, in the case of 35 mg. for one hour, would be 35 milligram hours, or in the case of 50 mg. for three hours, would be 150 milligram hours. The smaller the lesion and the lower its degree of malignancy, the shorter the milligram hours of exposure necessary, in terms of either a lesser amount for a longer time or a larger amount for a shorter time.

For example, a large epithelioma about 2.5 cm. by 1.75 cm. at the inner canthus involving the upper and the lower lid, (an actual case) received a total of 540 milligram hours divided over seven treatments over an interval of a few days more than two months. The lower the degree of malignancy in these cases, the less the urgency for extensive treatment, but the greater the degree and the extent of the lesion, the longer and the more frequently must one apply treatments. In general, radium in excess of 1000 milligram hours is, at one time, the top limit of application; in others, 1000 milligram hours are the total of the amount of treatment necessary when this is

divided into separate treatments. Figure 533 is the rather common type of basal-cell carcinoma with low malignancy, but with a most unfortunate and disproportionate incidence of recurrences. In these, the author's usual plan is to resect surgically with sharp dissection wide of the incision, correct the defect immediately, as in Figure 534, and then treat subsequently with radium using the pack method.

FIG 533 —Basal cell carcinoma.



A B

FIG 534 —Surgery for a malignancy resection A, resection and suture; B, completed and ready for early radiation. These broad flaps stand radiation very well.

Epithelioma of the deeper structures demands other treatment in addition to the local. This would include malignancy in the orbit before and after enucleation, recurrent malignancy after an enucleation, and malignancy involving the bones of the orbit. In these cases, radium is applied by

the pack method. This pack consists of 3 cm. (30 mm.) of felt, 2 mm. of rubber, 2 mm. of lead, and the brass capsule of 1 mm. thickness. The radium used is an average of 100 to 125 mg. This pack is bound firmly above the orbit so that the distance of the radium from the orbit is approximately 3.5 mm. In these instances the exposure of pack treatment is from fifteen to twenty-four hours or from 1800 to 2800 milligram hours. In an illustrative case of recurrent epithelioma of the inferior cul-de-sac, the patient had a total of 4485 milligram hours placed anteriorly, and 2760 milligram hours placed laterally. The treatment was further completed by 63 milligram hours placed directly upon the lid; *i. e.*, at a 3 mm. distance considering the filters which are used. The treatment of intra-ocular neoplasms, not gliomata, would be according to this technique.

The next type or instance is that of a deeper malignancy, as in a recurrence in the orbit. In these, the radium is directly implanted, *i. e.*, following enucleation or evisceration. Figure 535 illustrates such an instance prior to the evisceration. In such an instance, the radium is packed directly into the orbit within its capsule with 1 mm. of brass, 1 mm. of rubber, and 1 mm. of lead, using the usual capsules of 50 mg. of radium element at between 300 and 500 milligram hours approximately, *i. e.*, three to five hours of exposure per treatment, the total milligram hours being divided into three treatments.

FIG. 535 —Deep malignancy within the orbit.

FIG. 536 —Basal-cell carcinoma, after evisceration

Figure 536 is a case from the Wills Hospital, Philadelphia, of basal-cell carcinoma following evisceration, wherein it was treated by insertion treatments after evisceration. In these instances, one would use insertion applications of approximately 100 milligrams, properly filtered by brass, lead, and rubber, with an immediate total of approximately 1600 milligram hours. Subsequent radiation should follow after a week to ten days. Radium therapy is not recommended in a case in which extensive tissue has already been lost, as in Figure 537. In this instance, roentgen-ray rather than radium therapy accompanied by superficial desiccation cleared the malignancy. Flaps, as outlined in Figure 538, were used from the neck, the remaining portion then being grafted flat. (This patient died of hypostatic pneumonia while recovering from the flap grafting procedure, as seen in *F* of Fig. 537.)

The application of radium to intra-ocular tumors, as small sarcomata and gliomata, is a matter of either the pack treatment with the radium

element, or the intra-ocular implantations of radium emanations in the form of radon seeds. The pack treatment is from 100 to 150 mg. filtered through lead, rubber, and brass, at 3.5 cm. for twenty-four hour exposures; the ordinary course of treatment would be about six exposures over a period

FIG. 537.—Sclerotic form of basal cell carcinoma.

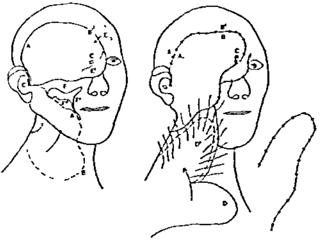


FIG. 538.—The technique for the neck-face flap in the case in Figure 537.

of six weeks. With children, slightly less than this should be used, *i. e.*, from 80 to 100 mg. of radium over twenty-four hours to a pack.

Stallard[1] discussed in great detail the treatment of malignant growths of the eye, and the adnexa of the eye. His paper was based upon the work in

[1] Radiant Energy, printed and published for Brit. Jour. Ophth., the Gifford-Edmonds prize essay for 1932, London, George Pulman & Sons, Ltd.

the treatment of these conditions at St. Bartholomew's Hospital under the care of Foster Moore. His work is quoted in detail here because of his work with radium emanations, or as he spoke of them, "radon seeds." Radon is the first product of radium disintegration. It is a true gas with a constant rate of decay in a sealed container so that at the end of forty days, it has lost 99.3 per cent of its radio-activity. Radon is used for intra-ocular implantation in all cases where it is not considered justifiable to remove an eye (the other having already been lost, as in glioma retinæ) or where enucleation has been refused and radium is to be used as the only other alternative.

Any portion of the eye is accessible for the introduction of the radon seeds, but in some instances the technique is a bit more difficult than in others. Figure 539 shows the front and side view photographs of roentgen-ray studies showing radon seeds, implanted through the optic foramen, following an enucleation. The optic nerve, at the time of the enucleation (an intra-ocular primary malignancy) was twice its normal size because of neoplasm extension, confirmed as such later. One seed lies 10 mm. from the foramen, the second 5 mm., the third in the foramen, and the fourth intra-orbital. They were implanted with the ordinary radon seed implanter.

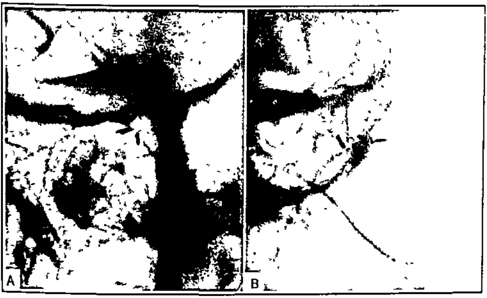


FIG. 539.—Radon seeds. *A*, Front view, group of seeds in the region of the optic foramen. *B*, side view, showing intracranial, extra-ocular and intraforaminal position of the four radon seeds.

An operative technique of Stallard is as follows:

A general anesthetic is preferred for children and a local for adults. Cocaine is used for the conjunctiva and novocaine for injecting Tenon's capsule or the vicinity of the ciliary ganglion. A suture is passed through the superficial layers of the sclera at the limbus and in the axis of the center of the neoplasm. This acts as a guide and traction suture. The sclera is exposed over the site of the neoplasm by undercutting a flap of conjunctiva and Tenon's capsule. This flap must be planned to give easy access to the site of the neoplasm, and to be so placed that the hole in the sclera is well distant from the conjunctival incisions. When the neoplasm is behind the equator similar conjunctival incisions placed further back are recommended. A large flap is best. It is advisable to place a suture before the radon

seed is inserted so that this is ready for tying immediately after the seed has been put in. The soft tissues may be retracted by a strabismus hook or small double blunt-ended hooks, and the globe rotated in the desired direction by pulling on the traction suture through the episcleral tissues. The hole made in the sclera should be of such a size as just to transmit the seed and no larger, and for this purpose cutting-edged needles, 3 mm. across at the widest part of the blade and bent at right-angles, or obtuse-angles, have been used; 3 mm. is the width suitable to surround the circumference of the standard sized radon seed. The needle is dipped into a solution of sterilized gentian-violet and then allowed to dry; by this means the cut edges of the incision are stained and the point of introduction for the radon seed thus marked. The site of the scleral incision depends upon the size of the neoplasm and whether it is necessary to insert one or more radon seeds. The ideal track for the seed is one directed toward the center of the neoplasm. In the case of small growths where only one seed is required, the center of the base of the neoplasm is the site of election, but in larger neoplasms it may be necessary to use more than one seed and to plan the direction of the tracts according to the size, base, shape, and position of the summit of the neoplasm. Cases in which it is believed before operation that the area of radio-activity for one radon seed may not reach all parts of the neoplasm, it is necessary to increase the dosage either by increasing the strength of the seed, or preferably by dividing the dose and inserting several seeds at approved intervals, the direction of insertion being estimated with regard to the shape of the growth. Also it may be advisable to vary the active length of a radon seed in some instances. The track of the scleral incision is continued into the growth for a short distance, as it has happened in one case at least that the neoplasm has been pushed forward and not transfixed by the blunt-ended seed when this procedure has been omitted. The needle is then moved right away from the instrument table and not used again. Such malignant cells as may be imposed on the lips of the scleral incision when the needle is withdrawn are killed by the approximation of the radon seed. So far, there has been no instance of extra-ocular extension at the site of the insertion of the radon seed discoverable either at a subsequent operation, or on pathological examination of the excised eye.

The seed is now taken in the introducing forceps and inserted through the scleral incision with a slight wriggling motion. This forceps is held with the blades at an angle corresponding with the angle of the needle, so that the seed is inserted in the line of the tract made by the needle. When the seed is safely engaged, it is pushed in gently by a dimple fashioned on the side or heel of the forceps until the end with the attached thread is just level with the sclera. There is, however, no harm in leaving part of the seed projecting above the scleral surface where it is not desirable to make a full insertion of the seed. The thread is black, and is cut so that 1.25 inches are still attached to the seed. This is buried under the conjunctival flap and can be readily located at a subsequent operation for the removal of the seed. In one instance the thread was brought through the corner of the conjunctival flap and strapped to the patient's (an infant) cheek with the idea of sparing a second anesthetic for the removal of the seed. (On the eighth day after operation this child developed a coryza and, later, chest complications and a conjunctivitis in the operated eye. Hemolytic streptococci were found in cultures from this eye. The seed was removed and later a corneal ulcer and intra-ocular infection occurred and the eye was lost through panophthalmitis.) It is quite possible that microörganisms tracked along the line of the thread and later entered the eye through the scleral incision. Although it is difficult to be certain that such was the cause of the panophthalmitis it is a safer procedure to bury the thread and suture the flap carefully and securely.

In one case the apex of the seed was within 4.5 mm. of the edge of the optic disk as estimated by the ophthalmoscope. The seeds have been kept in for eight to ten days in every case. For the removal of a seed the conjunctival flap is opened up and reflected. The black thread is located and the seed gently withdrawn by traction in the axis of its line of insertion. In no case has any complication such as hemorrhage, vitreous loss, escape of malignant cells, and breaking the thread at its attachment to the seed accompanied its removal. In one instance when another seed was inserted into the affected eye some eight months after the first, there was either an insufficient amount of neoplasm to support the weight of the seed or it was not gripped securely by the lips of the scleral incision, for it slipped into the eye

and could be seen suspended in the vitreous chamber with the black thread still attached to its end and passing out through the hole made in the choroid and sclera. It was recovered and made secure by attaching a small sterile rubber washer to its scleral end.

When it has seemed advisable to insert a second seed at a later date there has been no difficulty in finding the site of a former insertion and recognizing it by its dark color, even after seventeen months, as in one case In 4 cases radon seeds have been sutured to the sclera over the site of the neoplasm and not inserted A fine groove is made around the circumference of each seed at its center and in this groove a thin black silk thread is run and firmly secured by tying To one end of this thread a fine half-circle scleral needle is attached and the seeds are fixed to the sclera in the desired position by suturing them Technically, this procedure is more difficult than insertion, for the seeds are on the curved surface of the sclera and their spacing does not ensure a uniformity of the radiation The vitality of the overlying conjunctiva becomes impaired and the wounds do not heal well In another case, an intra-ocular sarcoma, sections were cut of an excised eye, which had been thus treated, and from a histological point of view, there was no evidence of any damage to the cells of the neoplasm by the rays months after the application of radium. The sclera was also unaffected, but there was necrosis of the overlying conjunctiva. However, in another case, an angioma of the retina, this procedure has apparently been effective in destroying the neoplasm so far as can be judged by clinical examination up to date.

The quantity of radium used is to be judged in part by the size of the neoplasm, in part by the radium sensitiveness of the neoplasm and also by considering the patient's age. According to Stallard, the area of tissue destruction for radon seeds is a 1.5 mm. radius for 0.7 millicuries, 3 to 5 mm. for 2 millicuries; and 8 mm. as the maximum area for any strength of radon seed. A 0.5 mm. platinum filter is to be used in all instances.

In recent years case reports are appearing, from time to time, in the literature of the successful treatment of choroidal malignant melanomata by surgical diathermy. It is apparently a logical procedure and probably in the years to come will be a valuable asset in the treatment of certain other forms of choroidal and other interocular neoplasms. Savin and Pritchard[1] discussed in detail their successful treatment of such an instance The outstanding point in their procedure was the preliminary "sighting shot" with the diathermy needle which was made before the coagulation diathermy was carried out. Apparently this, according to their statement, was made accidentally and through faulty localization. Be that as it may it is a valuable step in diathermy coagulation of minimal melanomata of the choroid. Regardless of how perfect the localization may be transsclerally, such a preliminary diathermy puncture can do no harm and will be valuable for the completion of the coagulation of the neoplasm. In their technique they used a flat Weve electrode (the 1940 model) on a Keeler diathermy unit with a scleral application of 120 milliamperes of current for three seconds. The same technique has also been reported for the treatment of angiomatosis retinæ. Guiton and McGovern[2] reported two such instances. It is possible that angiomatosis retinæ may be better handled in properly selected instances by diathermy than through the use of radium or of roentgen-ray therapy. The extent of a neoplasm may limit the application of the technique, but cases will appear wherein it might be seriously considered as a probable procedure.

To recapitulate—in general, in malignant lesions which are to be treated

[1] Brit. Jour. Ophth , vol 26, No. 12, December 1942.
[2] Amer Jour. Ophth., Ser. 3, vol. 26, No. 7, July 1943.

by radium or roentgen-ray therapy, we must consider: (1) intra-ocular sarcoma of the iris; (2) intra-ocular sarcoma of the ciliary body and choroid; (3) glioma retinæ; (4) angiomatosis retinæ; (5) a retrobulbar malignant neoplasm before enucleation; (6) a malignant neoplasm of the orbit, orbital neoplasm after enucleation, and recurrences of sarcoma and glioma of the retina; (7) epibulbar malignant neoplasm; (8) malignant neoplasm of the lids, (9) angioma of the lids, the conjunctiva, and the caruncle; (10) prophylactic doses of radium after enucleation for intra-ocular malignant neoplasms; and (11) a series of malignant diseases of the lymph and hæmatopoietic tissues.

In some cases of small, sharply circumscribed sarcoma of the iris, it is quite possible to do a complete iridectomy including that portion of the iris in which the lesion lies, so long as the position of the lesion is such that one can be assured of being able to cut through iris tissue at its root, which is not involved by neoplasm cells. If this cannot be done, the iridectomy is not permissible. If the iridectomy can be done, it should be followed by 1500 to 1800 milligram hours of radium therapy. This is to be seriously considered especially as the lesion may be a melanoma with a low malignancy tissue content. All other instances should have an enucleation followed by prophylactic radium treatment as long as the patient has a healthy opposite eye. Radium treatment by the pack method and the superficial attachment, over the lesion, of radon seeds are the methods for local treatment. Stallard reported cures following the use of 45 × 10 milligram needles on sorbo-sponge, 6 cm. thick, with eleven applications for 90 minutes, and one for 60 minutes, a total dosage of 218.75 milligram hours; and a second uneventful recovery wherein the radium was applied unscreened with a 7 mm. spatula for one application of 45 minutes, and a circular unscreened 1 cm. applicator of 10 mg., using two applications for 30 minutes and three applications for 60 minutes. In this instance, 45.25 milligram hours was the total dosage.

Sarcoma of the ciliary body is probably responsible for the largest percentage of extensive metastases. Differential diagnosis is between these conditions, that is, sarcoma of the ciliary body (malignant melanomata) and retinal separation. Transillumination is a valuable diagnostic aid. (See Chapter XXIV for the consideration of Retinal Separation.) Other factors are the duration of the impaired vision, the extent of retinal involvement, the tension of the eyeball itself, the condition of the vitreous, the presence or absence of the retinal tears, the distribution of the bloodvessels, the color of the separated retina, the presence of folds, and the absence or the presence of movement in these folds, etc., are of secondary importance. If a neoplasm is diagnosed as such, enucleation, followed by therapeutic radiation, is without a doubt the logical procedure. Here also, radon seeds may be attempted in cases where operation is refused or is not justifiable; not by implantation on to the ciliary body, however, but by the superficial attachment of a radon seed on the sclera over the site of the lesion. In Zentmayers'[1] classification of 118 cases of malignant melanomas of the choroid, 62 per cent lived five years after enucleation and 30 per cent lived ten years after enucleation; *i. e.*, in two-thirds of the cases the metastases occurred during the first five years, and on a ten-year period basis 30 per cent only remained cured.

[1] Personal communication.

Sarcoma of the choroid has three possibilities for therapy: (1) enucleation and prophylactic radiation; (2) the implantation of radon seeds into the lesion; and (3) lateral and anterior pack treatment by radium. The order of their preference is as stated. In spite of the position of this last possibility, much more can be said in its favor than such an abrupt dismissal. When one considers the tremendous percentage of such cases which terminate two to three years later with generalized liver and mediastinal metastases it seems logical to consider, first, massive radium irradiation, even to a deliberate destruction of the globe as an organ of vision—thereafter to proceed with the enucleation. This statement is made even considering that at the time of an initial enucleation, radium had been implanted into the orbit followed by roentgen-ray to the mediastinum and to the long bones. There is no doubt that our success in the treatment of malignancy of the ciliary body and the choroid is, at the best, a very sorry achievement. This reversal of therapeutic procedures, a direct intra-ocular implantation of a radium element (or emanation) cartridge will, without a doubt, destroy the eyeball, but if the intra-ocular neoplasm is truly primary, it should also prevent the inevitability of the late metastases seen when the reverse is the procedure carried out.

Angiomatosis Retinæ.—Plate VI is a fundus drawing of angiomatosis retinæ. The smaller of the two drawings illustrates at a focus the large peripheral tuft of neoplasm on the vein seen in the upper drawing passing toward the periphery at three o'clock. This condition, while rare, is specifically mentioned because it is so satisfactorily treated with roentgen therapy, on the one hand, and on the other, when untreated, terminates so pathetically in the death of the patient from intra-cranial cerebral or cerebellar extension (Lindau's disease). (See pp. 903 and 910.)

Glioma Retinæ.—It is in this condition that radon seeds have their greatest application and give best results. The question of immediate enucleation in the case of a unilateral glioma of the retina is not easy to answer. If one can be absolutely certain that the opposite eye is quite uninvolved, then perhaps enucleation is the best treatment. In bilateral glioma retinæ, however, or in the subsequent involvement of the second eye when the first has already been enucleated, then one should, without hesitancy, use a radon seed implantation. If the response to this form of therapy is not satisfactory, one can always proceed with an enucleation. Unfortunately in certain instances the subsequent course of the case proves that the enucleation failed to prevent intra-cranial extension. Fewell and Fry[1] were faced with a case of bilateral retino-blastoma in which the first eye was filled with a tumor mass with the second containing three very small lesions, the first of these present at the time of the first examination, the second later, nodules appearing two months later. The first eye was enucleated and roentgen-ray therapy was used for the second. There was an initial shrinkage followed by a later proliferation of the tumor, and the second eye had to be removed. The patient recovered without subsequent intra-cranial metastases. Fewell and Fry state:

As recently as 1929 Foster Moore stated that in a case of bilateral retinal glioma in which the tumor in the second eye was only slightly greater in size than the optic disk, on advice of colleagues at Moorfields, both eyes were enucleated. His comment on this procedure later was that, "in the light of our present experience, we

[1] Arch. Ophth., vol. 14, No. 2, August, 1935

should not again entertain the immediate removal of such eyes, nor consider it the proper procedure." Suffice to say that present opinion indicates that in the presence of an unaffected eye with useful vision, the affected eye should be enucleated; but in bilateral cases in which one eye retains useful vision, and in which ophthalmoscopic examination indicates that, in all probability the optic nerve head is not involved, the proper procedure would be enucleation of the first eye with irradiation of the second eye.

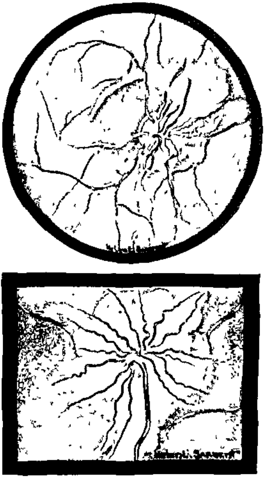
Recently, Stallard,[1] had to treat with radon seeds 2 children in whom the glioma was situated adjacent to the optic disk on the temporal side. In both these cases surgical access was gained as far as the dural sheath without apparent damage to any important structures.

A strip of heated stent dental wax 4 mm. wide and 2 mm. thick was taken and moulded to the sclera over the site of the growth and brought forward in the meridian of the neoplasm to a point about 3 mm. or 4 mm. in front of the equator. The posterior extremity of this strip extended to within 1 mm. of the dural sheath of the optic nerve. See Figure 540. The position of the lateral margins and anterior extremity of the stent strip were then marked by charring the superficial layers of the sclera with a few touches from the point of a fine heated probe. The strip was then removed and, with small eyeless cataract needles used for corneoscleral stitching, two sutures were passed through the superficial layers of the sclera about 2 mm. in front of and 3 mm. behind the equator as shown. The ends of these sutures were left loose. The posterior extremity of the stent was reheated in hot sterile water and a radon seed pressed into its concave or anterior surface, the seed being so placed that with the stent strip secured in position it lay over the neoplasm. The strip with radon seed was then placed on the sclera and final adjustments were effected by heating a broad flat spatula and pressing it against the strip at the requisite points. The two sutures were then brought over the stent strip, which was slightly heated and softened where the sutures crossed it so that they became embedded for about 0.5 mm. before being tied. The edges of the stent strip and any rough places were smoothed and rounded off by applications of the heated flat spatula. See Figure 541. The divided edges of Tenon's capsule, the external rectus muscle, and the conjunctiva were brought together and sutured. The radon seed remained firmly in position; and was removed on the eighth day.

Others have reported satisfactory results from the treatment of retinal glioma by roentgen-ray therapy (not radium therapy as recommended by Stallard) the most recent of these being the report of Martin and Reese.[2] They covered in detail the general principles of therapy for this condition. Figure 542 from their original article is a cross-section diagram showing the path and objective of the roentgen-rays as directed through each of three passable portals. They feel that, in general, the treatment should extend over a period up to twenty months, the intervals of rest being rather irregular and depending upon the reaction in the eyelids and the conjunctiva, and ophthalmoscopic signs of activity in the lesion. Martin and Reese believe that the frequency of the treatments and the increase of the dose should be as fast and the total amount as great as is compatible with the comfort and health of the child and with preservation of the integrity and function of the eye and adnexa. Under such a plan, the treatment will necessarily extend over a period of several months. One of their patients had almost complete regression at this time, after five months and 54 treatments. This was the most rapid regression in their experience. In one case, the patient received 13,000 r. to the temporal portal over a period of twenty months. The skin over that portal was blistered on two

[1] A New Technique for the Application of Radon Seeds to the Sclera in the Treatment of Glioma Retinæ, Brit. Jour. Ophth., October, 1938.
[2] Arch. Ophth., vol. 16, No. 5, November, 1936.

PLATE VI



Angiomatosis retinæ (von Hippel's disease). Lower illustration shows a tuft of peripheral neoplasm; the extension of vein, A, passing toward the periphery.

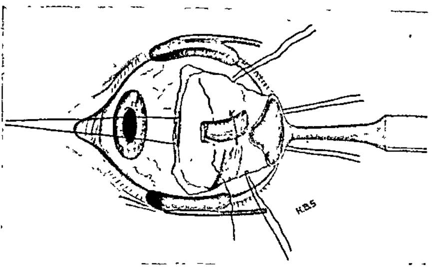


FIG 540 —The external rectus muscle has been divided and the eye rotated to the nasal side by a suture passed through the tendon of the muscle The insertion of the inferior oblique muscle and the posterior part of the sclera are exposed The strip of stent dental wax is shown in position above the insertion of the inferior oblique muscle (Stallard Brit Jour. Ophth , October, 1938)

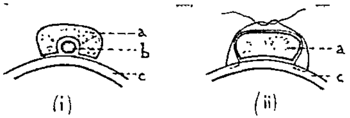


FIG 541 —*a*, strip of stent dental wax moulded to sclera *b*, radon seed embedded in stent, *c* sclera (i) is a cross-section through the strip of stent holding the radon seed, (ii) method of suturing the stent to the sclera (Stallard, Brit Jour Ophth , October, 1938)

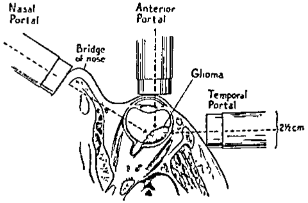


FIG 542.—A cross-section diagram showing the path and the objective of the roentgen-rays as directed through each of the portals in turn. (Martin and Reese; courtesy of Arch. Ophth., November, 1936)

or three occasions but healed within a few weeks after the treatment was halted. After the skin had healed, the treatment was resumed. Such large total doses in roentgens are meaningless unless considered in relation to the size of the portal, the size of the individual dose, and the length of the period for the total treatment. The cilia sometimes drop out with the first marked reaction in the lids, but usually return. Each portal, therefore, receives a treatment about every five to seven days. An individual dose of 250 r. (roentgen-rays at 200 kilovolts and 30 milliamperes, with a filter of 0.5 mm of copper and 2 mm. of aluminum) per treatment is rather less than can be tolerated, and with 400 r., the marked reaction in the skin and conjunctiva comes on earlier, so that it is too often necessary to interrupt the series in order to permit the reaction to subside. Usually they begin by including a direct portal to the eye as well, but after about 1800 to 2000 r. photophobia developed they had to discontinue the use of this anterior portal, and proceed with the other two alone. These figures for dosage and this discussion apply only to circular portals 2.5 cm. in diameter. With portals of different sizes, a different set of figures for dosage would apply.

This type of therapy as outlined is probably the most extensive and heaviest irradiation which has ever been carried out. Martin and Reese state frankly that glioma retinæ is not radio-resistant contrary to their earlier conviction, but that it was necessary to employ highly fractionated large total doses through limiting portals so as to confine the beam of roentgen radiation as much as was possible to the region of the growth itself. All cases of glioma retinæ should have prophylactic radium therapy or roentgen-ray therapy to the orbit following necessary enucleation.

The combined intra-cranial and orbital operation for retinoblastoma, recently recommended and reported by Ray and McLean,[1] is one possible means in cutting down on the altogether too high mortality incidence of this condition. McCrea showed a mortality rate of 40 per cent, which, it seems, can and should be lowered. The operation is to be done by a neurosurgeon and as such belongs within his field of surgery.

Angiomatosis retinæ, before the use of radon seeds, were universally hopeless and ultimately ended in Lindau's disease. The recovery that Stallard reported followed the implantation of three 5 millicurie seeds, 10 mm. from the limbus in the two-thirty o'clock meridian. Six months later the fundus showed no evidence of neoplasm, the site of which was represented by a pale area stippled with flecks of brown pigment. The vessels which originally supplied the neoplasm were completely obliterated.

Malignant neoplasms of the orbit which appear prior to enucleation are most difficult to diagnose. The retrobulbar implantation of radium element in cartridges and/or deep roentgen-ray therapy should be utilized in these instances, only after the exploratory orbitotomy has been done. Even if the surgeon is reasonably satisfied that he has obtained a complete surgical extirpation, it is still quite necessary to continue with the radium or the roentgen-ray in every instance of malignancy. Cases inoperable from the start should have an immediate therapeutic evisceration of the orbital contents, even to a complete exenteration if indicated, and radium therapy thereafter. Retrobulbar malignancy, which extends into the orbit from the continuous tissues as the nasal accessory sinuses, adamantin-

[1] Ray, B. S., and McLean, J. M., Arch. Ophth., vol. 30, No. 4, October, 1943.

oma from the jaw, meningioma from the intra-cranial cavity, and metastatic lesions from a distant point of the body are hopeless from the start.

Malignant neoplasms of the orbit which appear as recurrences following an enucleation should be treated by the implantation method, with the addition of any surgery necessary for the removal of gross bony extension and especially the removal of sequestræ when these appear.

Epibulbar malignant neoplasms are amenable to treatment and usually give a very high percentage of complete recoveries. Stallard treats them with circular, square, and rectangular brass applicators mounted with a button and containing unscreened radium salt This is held in place with varnish in a shallow trough on a flat surface. The 1 centimeter circular applicator contains 10 milligrams of radium salt and the square and rectangular applicators (2 × 2 and 2 × 1) contain 20 milligrams of radium salt. These applicators are usually screened by 2 mm. of lead foil, 25 sheets of black paper (to remove the negligible alpha rays) and a covering of sheet rubber; 1 mm. of silver with 26 sheets of black paper and 1 sheet of rubber. Thirty-five to 100 milligram hours, in fractionated doses, of three applications is probably the maximum necessary for these cases In some instances, the epibulbar neoplasms may be so extensive that pre-irradiation removal is indicated. The operator should use a fine cautery tip for this and not sharp dissection.

In cases of malignant neoplasms of the lids, one should not only consider radium and roentgen-ray therapy alone or those combined with surgical removal, but also their removal by surgical unipolar electrical fulguration, *i. e.*, diathermy coagulation current. Many small neoplasms well away from the lid margin so that subsequent ectropion cannot occur are very nicely treated by this means. The radium therapy is either by direct contact or through the pack method using from 20 to 50 mg. of radium for a total of 200 to 500 milligram hours over a period of a few days to several months depending upon the size of the lesion and the rate of response from the initial treatments.

Angiomata of the lids of the conjunctiva and of the caruncle respond very well to radium therapy. Fifty mg. tubes of radium emanation properly screened can be attached directly to the lesion using from one to three treatments for a total of 30 to 100 milligram hours depending wholly upon the size of the lesion. In general, hemangiomata when first treated respond by dilation of the vessels with a later complete sclerosis of these vessels and vessel channels. Brown pigment present in the hemangioma before the treatment may remain after radium therapy

Prophylactic treatment of the orbit following an enucleation for an intra-ocular neoplasm should be carried out immediately after the enucleation, the radium being implanted while the patient is still in the operating room. The radium element should be used in 25 or 50 mg. cartridges for a total of 1800 to 3000 milligram hours and properly screened to prevent unusual and unnecessary necrosis of healthy tissue; 1000 milligram hours is the usual initial dose, the remainder at two weeks intervals. This type of necrosis is very slow in recovering and if this complication does occur, one should keep the socket as clean as is possible by frequent irrigation with a weak solution of potassium permanganate and continue a dressing over the palpebral fissure with a light gauze packing within the socket. After every enucleation for intra-ocular malignancy, the operator should

insist upon an early microscopic examination of the optic nerve stump to determine the presence of migrating tumor cells. If these are found to be present, further radium therapy will be necessary.

The treatment of lymphoma or lymphoblastoma including: (1) Hodgkin's disease—sclerosing lymphoblastoma; (2) lymphoendothelioma; (3) lymphosarcoma; and (4) lymphatic leukemia, is usually a hopeless matter. (See section on Exophthalmos, page 56; also page 897.) The prognosis is poor, in that the disease is usually fatal. In addition to the general treatment which is carried out by the medical men for these conditions, roentgen-ray therapy should be used in large total fractionated doses. This will probably give temporary relief, and it does reduce the size of the lesions, though unfortunately not permanently so.

PLASTIC REPAIR OF TUMOR SITES

(SEE SECTION ON PLASTIC REPAIR OF THE LIDS)

Most of the cases coming within this class are connected with the operative treatment of epithelioma, the remaining, with orbital repairs following the complete evisceration of all of the orbital contents because of retrobulbar, periosteal, and intra-ocular malignancy. In the former case, that of epithelioma, the plastic work is best done at the time of the removal of the tumor. If the surgeon simply removes the growth, and closes the operative regions, severe scarring will result, with malposition of all of the tissues, making later plastic repair quite difficult. It is of interest to note that de Lapersonne advocates the use of true early autoplasty to correct

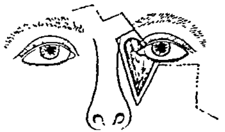


FIG. 543.—Dissection for the repair of an upper or lower lid at the inner angle following a resection for epithelioma. (Courtesy of P. Blakiston's Son & Co.)

defects from injuries at the time the accident or wound is at first treated, in this way obtaining immediate primary healing and the prevention of later severe deformities due from the extensive loss of tissue. He also recommends saving all possible tissue of the lids at this time, even the roughest of skin tags, these to be combined with pedicle and sliding flaps.

Throughout the various subsections of this text, malignancy has been considered as part of the material presented. This is seen under lid reconstructions, lid deformities, the use of sliding flaps (Imre's technique), and conjunctival defects. A technique representative of the group is fittingly presented here in this detailed subsection. It is rather similar in part, and probably inspired by other procedures, though of itself peculiarly individual to McLean.[1] Figure 544 illustrates the stereoscopic pictures of his case

[1] Am. Jour. Ophth., 24, No. 1, 45, January, 1941.

from the Wilmer Ophthalmological Institute, showing a rapidly developing growing mass on the right upper lid, 14 mm. by 5 mm by 5 mm in size, involving both the skin and the conjunctival surfaces. Figure 546 shows the specimen following a complete resection according to McLean's sketches, Figure 545. Lateral incisions were made through the underlying tarsus and the conjunctiva involving the greater part of the lid surrounding the tumor.

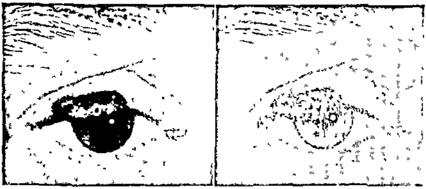


Fig 544.—Stereoscopic appearance of the tumor (McLean, courtesy of *Am. Jour Ophth*).

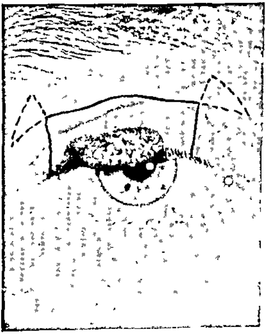


Fig. 545 —Full thickness excision of lid, full lines and skin relaxation *triangle also, dotted* lines, these triangles were resected, but only as skin tissue (McLean, courtesy of Am Jour. Ophth)

As the superior incision was finished, as McLean described his technique:

The end of the levator muscle was carefully isolated and secured. The lower lid was then split into two layers The under one, consisting of tarsus and conjunctiva,

was mobilized, its edge freshened and attached to the levator muscle above with buried gut sutures. A strip of orbicularis muscle was isolated from the remaining root of the upper lid and swung down over the new-formed tarsal plate. Loose skin

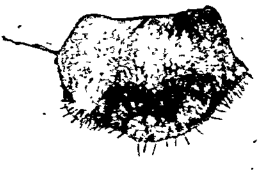


Fig. 546.—Tumor and lid portion following resection (McLean, courtesy of Am. Jour. Ophth.).

Fig. 547.—A, appearance eight weeks after operation before the lid adhesions were removed; B, immediate postoperative result; C, postoperative result showing the ability to close the new-formed lid (McLean, courtesy of Am. Jour. Ophth.).

between the relaxation triangles was mobilized and used to cover the denuded area, the lower border being sutured with fine silk to the edge of the lower lid. The other skin incisions were similarly closed with fine silk and a pressure dressing

applied. Pathological examination revealed a basal-cell carcinoma Healing was uneventful and the lids were left closed for eight weeks. The lids were then separated under field-block procaine anesthesia. Opening and closing of the lids were well performed. Six weeks later a lash graft from the opposite brow was placed in the upper lid according to the method of Wheeler to complete the restoration of preëxisting structures. There was complete restoration of sensory as well as motor function.

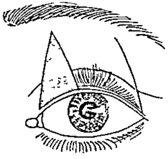


FIG. 548.—Landolt's blepharoplasty. First step (Török and Grout)

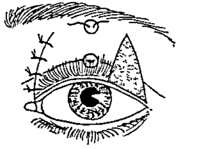


FIG. 549

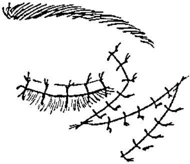


FIG 550

FIG. 549.—Landolt's blepharoplasty. Result. (Török and Grout)
FIG. 550 —Richet's plasty. Result. (Török and Grout.)

Figure 547, A, shows the case before the tarsorrhaphy was sectioned; B, immediately after that; and C, the postoperative closure possible in the new formed lid. It illustrates very well the use of a combined conjunctival and skin technique for the treatment of these conditions.

If it is thought advisable to follow these reconstructions with roentgen-ray therapy, one must be certain that complete healing has occurred in the transplanted tissues, because rapid devitalization does occur in grafted areas with premature roentgen-ray therapy.

Figure 543 describes the repair of the upper and lower lids at the inner canthus following the removal of a lid epithelioma. It is not anticipated by the author, nor by the operator of this case, Roy of Montreal, that it will suffice and answer for the correction of every case of lid epithelioma but it most certainly should suggest to the ophthalmologist a scheme for his case under consideration.

The use of the classical Y-Y incision and sutures can be applied for moving relatively large portions of soft tissue toward or away from an area involved.

Pedicle flaps from the adjacent regions, free skin Ollier-Thiersch, and dermo-epidermic (Wolfe) grafts are all available, according to any one of

the many methods recently discussed. These pedicle flaps may be taken from the neck or from the chest by a delayed flap transplantation method in the case of extensive defects under correction. Dieffenbach's plasty, as modified by Arlt-Blaskovics is to cut the flap with a narrow pedicle so that

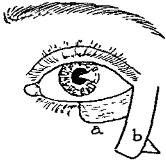


FIG. 551

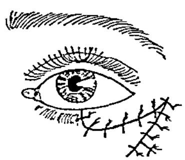


FIG. 552

FIG 551 —Modified Richet's plasty for lower lid. First step (After Blaskovics, from Török and Grout)

FIG 552 —Modified Richet's plasty for lower lid. Result. (After Blaskovics, from Török and Grout.)

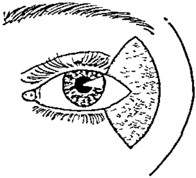


FIG. 553.—Kovacs' plasty. First step.

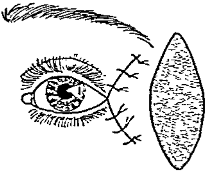


FIG 554.—Kovacs' plasty. Result.

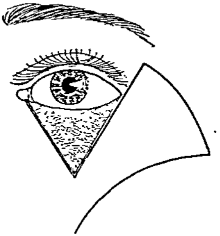


FIG 555

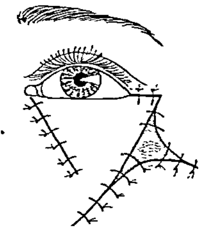


FIG. 556

FIG. 555 —Arlt-Blaskovics' modification of Dieffenbach's blepharoplasty. First step.

FIG. 556.—Arlt-Blaskovics' modification of Dieffenbach's blepharoplasty. Result.

the entire flap has a hatchet-like shape. Landolt suggested sliding over the unoperated portion of the lid (Figs. 548 and 549), the secondary defect being filled in by a small temporal flap or through a modification of the method of Richet, who uses descending pedicle flaps with their pedicles at the canthal angle (Modification of Blaskovics) or two flaps, descending and ascending with an interchange in their original position (Figs. 550, 551 and 552).

The methods of Celsus-Knapp and of Burow, singly or combined, all are worth consideration. They are not new methods, but they are invaluable *for the immediate plastic correction of tumor sites.*

For the smaller defects present at the canthi, the canthoplasty of Hasner is convenient. He uses a boot-jack-shaped flap and turns this into the canthus. Blaskovics also modified this somewhat by turning in upon the canthus a solid triangular flap to cover both upper and lower lids at the same time. Kovacs recommended a strap flap for the outer canthus (Figs. 553 and 554).

Mobilio has modified these plastics somewhat in a case which he reported.[1] After the removal of the epithelioma a defect was present, occupying the middle third of the ciliary margin of the left lower lid. The remaining skin margins when approximated formed an area about one-half of the normal surface of the eyelid. A canthotomy was done and the skin incision of this prolonged in the line of the palpebral fissure upon the temporopalpebral area for 5 cm. A second incision was made at the outer extremity of this, directed obliquely downward and outward. In this way, a cutaneous flap was outlined. This was lifted and moved in toward the inner edge of the coloboma. By a suture the outer extremity of the superior border of this was joined to the lid at a point corresponding to the external commissure. The remaining two branches of the coloboma were then closed and the lid fixed below by a retaining suture, and another near its free border. The conjunctival fornix was then restored by deep sutures. The outer triangular defect was well undermined upon its external edge, and then turned inward and closed with interrupted silk sutures. In this way the line of tension sutures was displaced from the flap upon the lower lid, to a certain extent, and later deformity thus minimized. This case of Dieffenbach plasty shows how easy it is to apply one of the many different forms of sliding and pedicle flaps to close an operative defect.

Wright reports Buediner's modification of the classical Dieffenbach blepharoplasty.[2] In this, after the triangular resection of the lower lid and its conjunctiva and before the flap outline is moved into position, the tarsus and the conjunctiva are replaced by a composite flap from the back of the ear. This consists of semi-lunar pieces of skin and cartilage, attached to each other, with a common straight edge somewhat shorter than the edge of the cheek flap. The skin is approximately three-fourths of a circle, the cartilage one-fourth of a circle. This flap is applied to the deep surface of the skin flap from the cheek, straight edge to straight edge, the surface epithelium of the ear towards the globe. It is held in position by two or three double-armed sutures passed through from behind forwards, a short distance below the free edge, and tied externally upon beads. The Dieffenbach flap is then completed, and the triangular area filled in as soon as is

[1] Giro. di ocul., Naples, 3, 91, 1922.
[2] Brit. Jour. Ophth., London, 8, 58, 1924.

possible. When one considers the severe defects possible because of extensive malignancy, then it will be appreciated that large and extensive flaps oftentimes must be used from the different available regions no matter how distant (Figs. 555 and 556.)

The second type of postoperative deformities presented has to do with socket eviscerations. The repair of these, unfortunately, cannot be done until some time after the primary operation, for the operator must be certain there are no malignant recurrences within the orbit.

When the time is right for restorative surgery, the socket will be filled with scar tissue, the outer canthus deformed, and the lids in complete entropion The first stage is the removal of all of the contained scar tissue. After that, correction may be obtained by the implantation of a graft over a mold, or by the use of a pedicle flap into the fundus of the socket. The lids must be released, and their raw posterior surfaces covered with epithelium. This may be done at the same time the fundus is repaired with the graft over the mold, or according to the symblepharon method outlined by Morax. The case will be completed after the repair of the canthus by one of the several methods already explained. In these cases the plastic operative work should not be started until the patient has completed a course of treatment by radium or by roentgen-ray.

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Laboravi. Accipite usum.

* * * * * *

AUTHORS' INDEX

GENERAL INDEX

(See Table of Contents, pages 7–13, inclusive. Further alphabetical listing of the information and the subjects as they appear in the Table of Contents is unnecessary and would be repetition. Additional reference to the Authors' Index is invited as is necessary. The index, further, as it appears below, is additional reference list to the two quoted.)

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